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ABSTRACT

This book is a curriculum guide for seventh-grade general science. It contains four units of chemistry, physics, biology, and earth science. Each unit is divided into sections covering major concepts. Each section contains science activities and contains explanations of objectives and implementation of the lesson. At the end of each section are review exercises, research topics, and resource materials. Also following each unit is a suggested unit examination. (MR)

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SCIENCE

Grade 7

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SCIENCE:

Grade 7

Bureau of Curriculum Development
Board of Education • City of New York

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FOREWORD

In these times of great scientific advancement and opportunity, we are increasingly dependent upon a scientifically literate population. Our young people must be led to explore, to discover and to understand the scientific ideas which will be of value to people in a changing world.

The new science course of study for grades 7, 8, and 9 is part of a K-12 science program which is based upon the sequential development of selected concepts from four major science areas.

This bulletin represents a revision of grade 7 science. It features careful experimentation under classroom conditions and is designed specifically to meet the needs of students of varying abilities. To implement this bulletin, it is expected that schools and districts will set up in-service training workshops for teachers.

The personnel who participated in this project are to be congratulated. They have prepared an adaptation of the science course of study which should provide worthwhile experiences for intermediate and junior high school students in an urban community.

SEELIG LESTER
Deputy Superintendent of Schools

ACKNOWLEDGMENTS

The planning and design of this bulletin, part of the Science: Grades 7-8-9 Curriculum Development Project, were under the direction of David A. Abramson, Acting Director of the Bureau of Curriculum Development; and Harry Milgrom, Acting Director of the Bureau of Science. Deputy Superintendent Seelig Lester, Office of Instructional Services, provided general supervision for the project.

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Consultants for the committee included the following: David Katz and Samuel Malkin, Curriculum Coordinators, Julius Schwartz, Science Consultant, and Leonard Simon, Acting Assistant Director, Bureau of Curriculum Development; and Robert L. Lipton, Assistant Director, Bureau of Science.

Science: Grade 7 combines the "short" and "long" forms into a single integrated teacher's guide for use with all students. Grateful acknowledgment is given to the following teachers and supervisors who prepared the two original forms: Alfred A. Beck, Kenneth Chevers, Charles A. Coleman, Constantine Constant, Malcolm Cooper, Ronald Dermer, Murray Ehrlich, Milton Forrest, Mary Gavin, Frank Gray, Peter Greenleaf, Hugh Griffith, Martin Groffman, Ralph Harrison, John Hodnett, Paul Kahn, George Kanstroom, Bernard Kauderer, Max Kobre, Leon Kurtz, Anthony La Sala, Arthur H. Lefgren, Alfred A. Leichtman, Doris Lynk, Jesse Nitzberg, Joseph M. Oxenhorn, Alice Pataky, William Poppel, Maria A. Soscie, Joseph Sferraza, Eugene Stern, Jules Weisler, and Louis Weiss.

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Introduction

This publication constitutes an important segment of a sequential K-12 science curriculum for the New York City public schools.

The original grade 7 science programs described in the "long" and the "short" forms have been revised and combined in this bulletin. The teacher now has a program which meets the needs of all children. The design provides a set of basic experiences and instructions for which all pupils are responsible. Pupils are frequently exposed to familiar objects from their environment as a basis for study. New ideas, laboratory skills, and science vocabulary are introduced at a pace which permits easy assimilation by the pupils. Understandings and interrelationships are constantly reinforced through frequent referral to previous studies.

In addition, each lesson contains concrete suggestions (italicized) to the teacher for stimulating a more in-depth study and for providing enrichment activities for those youngsters whose interests and abilities warrant them.

OBJECTIVES

The objectives of the intermediate and junior high school course of study reinforce the aims of general education. In addition, they include the objectives that are specific to the study of science. They seek to have the pupil continue to:

- Develop the concepts, skills, knowledges, and attitudes which were begun in K-6
- Develop a firm scientific foundation, including laboratory skills, upon which the program in grades 10 to 12 can be built
- Explore the various scientific disciplines for the development of individual interests and abilities
- Explore the possibility of a satisfying and challenging career in a scientific field
- Understand science as a unified whole by perceiving interrelationships among the four fields of science
- Appreciate the role of science in the progress of civilization and in the development of our technical society

- Understand the methods employed by the scientist in his attack upon problems affecting the health and welfare of the human race and to rely upon his findings
- Apply the methods and attitudes of the scientist, where possible, as a way of life.

INNOVATIONS IN SCIENCE 7-8-9

To attain these goals, the program offers a body of up-to-date subject content that should be interesting and exciting to teachers and students alike. The course of study is set forth logically and in detail to provide adequate assistance and direction to new teachers.

The science fields provide particularly fine areas for experimentation because they contain many concrete, self-motivating experiences upon which a high degree of understanding can be built. Science materials and equipment are colorful, interesting, challenging, and readily available. The science classroom provides a unique environment in which the youngster can observe and experiment with concrete materials to solve problems meaningful to him.

Ample opportunities are provided to enable the pupils to pursue the study of science at a pace and to a depth that match their own interests and abilities.

To accomplish these aims, the following innovations have been introduced:

1. EMPHASIS UPON CONCEPTS: The material calls for an understanding of the important concepts underlying each of the four scientific disciplines as well as the interrelationships among them.
2. FOCUS ON THE SCIENCE: Units of fundamental science content from the fields of chemistry, biology, physics, and the earth sciences are presented separately in the seventh, eighth, and ninth grades. Each unit is developed lesson by lesson, building upon previous concepts and expanding upon the problem-solving abilities of the pupils.
3. INTEGRATION OF LABORATORY WORK: Student laboratory investigations and experimentation are considered an integral part of the science teaching program. Laboratory lessons, therefore, are

included in each unit where direct involvement by the students will make the greatest impact. Each discipline contains approximately six single-period laboratory lessons. The laboratory activities planned fit into a 40-minute period. Where double laboratory periods have been scheduled, the teacher may use the additional time for classroom discussion and demonstration.

4. STRESS ON CRITICAL THINKING: Emphasis is placed upon science as a method of thinking, of investigation, and of operation. To implement these aspects, the committee has selected the scientific concepts for their contribution to a better understanding of the ideas of science. To this end, a definite limitation has been placed upon the total content in order to give the teacher time to implement the program.

FORMAT

In keeping with the objectives and innovations of the present course of study, a distinctive format was developed. Its special features include:

- Topical outlines
- Sequential units in each of the four science areas
- Division of each unit into sections for ease in reviewing and testing
- Outcomes listed for each lesson of every unit
- Each section designed to be a complete lesson
- Direct reference to interrelationships among the sciences as they occur in the development of the lessons
- Designated laboratory lessons including explanatory notes for the teacher and worksheets for the pupils
- Logically developed classroom lessons with specific content, methodology, and techniques
- Supplemental activities such as assignments, questions, reports, and projects
- Designated lessons, identified as "Review and Reinforcement" lessons, offer the teacher frequent opportunities for experimentation, enrichment, testing, and review
- Groups of basic lessons required of all students. Enriching activities extending the scope and depth of the lessons appear in italicized print.

The teachers' guide provides for two basic types of science lessons described in the sections that follow.

THE CLASS LESSON

About 24 lessons comprise each of the four units. Eighteen may be classified as classroom recitation lessons. Five to six lessons are identified as laboratory lessons. In addition, three lessons are "Review and Reinforcement" lessons. As suggested in the introduction to these lessons, the teacher may select one or more of the activities listed.

Each lesson is numbered sequentially and tailored to fit the standard 40-minute period. Following generally accepted planning procedures, the lessons include a statement of the aim in question form, motivation, development, and a terminal summary. Among the specific techniques that may be found within the broad classification of classroom lessons are demonstrations, discussions, lectures, reports, and reviews. In order to help the inexperienced teacher and the one whose area of specialization does not coincide with that of the unit, each lesson has been worked out in detail to include methodology, techniques content, and outcomes.

The class lessons foster an enquiring attitude on the part of the pupils through thought-provoking questions and demonstrations. Experience shows that short question periods at the start and at the conclusion of lessons are highly effective in orienting the attitude and thinking of students to the scientific solution of science problems.

Since reporting is an important pupil activity in the units, the teacher should acquaint the pupils with reliable sources of information and with the proper form, content, and structure of a report. Stress should also be placed upon effective presentation of reports to the class. Finally, the recitation lessons developed in the materials are not intended to be employed as a substitute for individual lesson planning. Lesson plans should be geared to the capability and personality of the individual teacher. They should help meet the specific needs of the students in each class.

THE LABORATORY LESSON

Individual laboratory lessons are among the most effective means of reaching many of the objectives of science education. Students learn best by actual experience. To achieve these goals, pupils should be directed by specific instructions in a step-by-step manner. After the planning stage, pupils should be encouraged to carry out their own plans for performing experiments.

However, for successful planning, the teacher must provide the required background techniques and information prior to the laboratory experiences. In addition, adequate safety instruction is most important in laboratory work which allows relative freedom to the children. Each teacher must secure a copy and acquaint himself, as well as the children, with the contents of the Board of Education safety booklet.

Approximately one period per week is devoted to laboratory investigations by the students. The laboratory lessons contain explanatory notes to the teacher and worksheets for the pupils. Initially, the worksheets contain detailed step-by-step procedures. Later, they give way to less detailed problem-solving instructions. The laboratory lessons are not all of the problem-solving variety. Some lessons offer the opportunity to acquire techniques or skills. Other lessons are designed to teach concepts in a step-by-step manner. The laboratory lesson is divided into three phases: the introductory or preparatory phase, the work or laboratory phase, and the discussion phase. During the introductory interval, it is suggested that materials be distributed quietly, on trays. While this is going on, the teacher should guide the class to delineate the problem and to suggest possible methods for its solution. For the laboratory period, the class should be divided into groups of 2-4 pupils depending upon the availability of equipment and materials. It is suggested that the pupils retain their original groups and select a group leader who will be responsible for the security and return of the equipment. Pupils should be told to work together, to discuss and rotate tasks, and to call upon the teacher for help as required. Normal classroom decorum should be maintained during the laboratory interval in order that the pupils may hear instructions from the teacher.

It is also suggested that the teacher and laboratory specialist circulate about the room to detect difficulties and to encourage and assist individual pupils as needed. Some time should be provided at the end of the period for the discussion of the procedures, observations and conclusions, and for answering questions. A good laboratory session points up the new problems that may be opened for further investigations. Once a class is properly trained in laboratory decorum and responsibility, the laboratory work should proceed with little difficulty and with much benefit.

Every pupil should be encouraged to keep a science notebook with a laboratory section in which to record his data, observations, conclusions, and answers to the summary questions for each laboratory lesson. In addition, if a pupil is alerted to spot new problems as he analyzes the data, he will suggest hypotheses for their solution. These may become the bases for additional experimentation, project, and laboratory work.

HOW TO USE THIS BULLETIN

Although the lessons are only suggestions, the teacher may use them with confidence. The order of presentation, and the motivation and activities may be adapted on the basis of experience, nature of the class, and creative bent of the teacher. However, the basic minimal outcomes should remain intact. Enrichment activities, in harmony with the aim and the outcomes of the lesson, are included to meet specific needs. The New York State handbooks in General Science, Chemistry, Physics, Biology, and Earth Science are excellent sources of pertinent activities.

The teacher who is a beginner in one or more of the sciences is advised to follow the lessons closely. To insure a measure of success, the demonstrations and laboratory exercises must be tried in advance. Teachers are advised to schedule frequent reviews, to administer short quizzes, and to examine notebooks regularly.

The syllabus has been so designed that the laboratory lessons may be presented at the time specified or within a reasonable time thereafter. Laboratory lessons should not be undertaken before the student has learned the necessary techniques and preparatory content.

ORIENTATION

Experience has shown that the pupil should undergo a period of introduction and orientation before embarking upon any course of study. The teacher will be in the best position to judge the time and the nature of the preliminary material to be introduced. However, the following suggestions may prove helpful in the task of orienting the pupil to the study of science and to assuming his responsibilities.

——— Open the course with a planned motivation. Some teachers prefer discussions of summer science experiences or expectations from the study of science. Others capitalize on interesting science current events.

——— Discuss the types of science lessons, particularly the laboratory exercises.

——— Practice forming laboratory groups and preparing for laboratory work.

——— Acquaint the pupils with the course requirements: notebooks, contributions to class discussion, reporting, assignments, regular study, quizzes and examinations.

——— Illustrate, define, and examine the scope of the four sciences to be studied.

——— Develop a daily awareness of the degree of understanding of the content and processes of science on the part of the students and the measures to be taken to meet specific problems that may arise.

Unit I

CHEMISTRY

Elements

Compounds and Mixtures

Atomic Theory

IMPORTANT NOTE TO THE TEACHER

The sections of the text which are printed in italics (the type used in this note) are intended as enrichment material.

ELEMENTS

Suggested Lessons and Procedures

1. WHAT IS MATTER?

Outcomes

- Anything that has weight and occupies space is called *matter.*
- The states of matter are *solid, liquid,* and *gas.*
- *The state of matter is dependent upon the rate of movement of its particles.*

Motivation

Ask the class to imagine that a pan of water is being heated. The pan of water can be weighed with a scale. Its size can be measured with a ruler. The one item that cannot be weighed on a scale or measured with a ruler is its heat. How is heat comparable to light and electricity? What special name do we give to light, heat, and electricity?

Development

1. Perform the following demonstrations:
   a. Display three plastic bags. Place a block of wood in one bag. Half-fill the second bag with water. Blow up the third bag with air. Tie the open end of each bag with string.

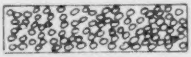
b. Ask the pupils to describe the shapes of the three objects inside the plastic bags. Establish that the wood block has a definite shape, the liquid takes the shape of its container, and the air takes up the entire container.

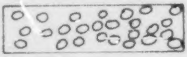
c. Weigh the three bags separately and record weight of each.

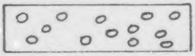
2. Lead the pupils to conclude that the wood block, the water, and the air take up space and have weight. Anything that has weight and occupies space is called *matter.*

3. Indicate that the wood block is *solid,* the water is *liquid,* and the air is *gaseous.* Establish that the three forms of matter are: *solid, liquid,* and *gas.* Ask the pupils to name some solids, liquids, and gases found in the school.

4. *Explain that all matter is made up of tiny particles which are in constant motion. A solid has a definite shape because its particles move very slowly and are very close together. A liquid takes the shape of its container because its particles move faster and are farther apart. A gas takes the shape of the entire container because its particles move very fast and are very far apart.*


Solid


Liquid


Gas

Summary

1. Have the pupils use check marks to complete the following chart:

FORMS OF MATTER			
PROPERTY	SOLID	LIQUID	GAS
Takes up space			
Takes shape of container			
Fills container			

2. Anything that has weight and takes up space is called ________.

3. The three forms of matter are ________, ________, and ________.

Homework

List five solids, five liquids, and two gases found in the home.

Materials

3 plastic bags	String
Block of wood	Spring balance

2. HOW CAN MATTER BE MADE TO CHANGE ITS STATE?

LABORATORY LESSON

Outcomes

- A substance can exist in more than one form or state.
- The state of matter can be changed by adding or removing energy.
- *Changes of state occur at specific temperatures.*

Motivation

Display an ice cube and some water. Establish that these are different forms of the same substance. Ask, "How can we change water from one state to another?"

Development

1. Distribute materials to each group of pupils.
2. Review the safety precautions for handling the alcohol lamp and for heating materials.

Homework

Carefully uncap a bottle of cleaning fluid which you have at home.

1. What is the state of matter of the cleaning fluid?
2. Describe the odor.

3. Explain why you can smell the substance without putting the liquid directly to your nose. What change of state must be taking place?
4. *Research problem:*
   - *a. What is sublimation?*
   - *b. What changes of state take place when snowflakes are formed?*

Materials

Ring stand
Iron ring and clamp
Alcohol lamp

250ml beaker
Glass plate
Ice cube

Wire gauze
Thermometer

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 2

Problem: How can matter change from one state to another?

Materials

Ring stand
Iron ring and clamp
Alcohol burner

250ml beaker
Glass plate
Ice cube

Wire gauze
Thermometer

Procedure and Observations

1. Attach the iron ring and clamp to the ring stand.
2. Place the wire gauze on the ring.
3. Place the alcohol lamp under the wire gauze. *Do not light the lamp.*
4. Adjust the height of the ring so that the gauze is one inch above the alcohol lamp.
5. Place the beaker containing the ice cube on the wire gauze.
   The state of matter of the ice cube is _______________.
6. Place the thermometer into the beaker and leave it there. The temperature is ____________ *degrees F*. Let the ice cube melt slightly before going to step 7.
7. Your teacher will inspect your set-up and light the alcohol lamp. Heat the beaker until the ice is completely melted.
   As the ice cube is heated, _________________ appears in the beaker.
8. *The temperature in the beaker now is ____________ degrees F.*

9. Continue heating the beaker for several minutes. Carefully hold the glass plate over the beaker.

   The water in the beaker changes into ______________, which is a gas. When this gas touches the cool glass plate, it changes into ______________.

10. *The temperature of the water while it is boiling is* ____________ degrees F.

Conclusions

1. When the ice (a solid) is heated, it changed into a ______________.
2. When the water (a liquid) is heated, it changes into a ______________.
3. When the steam (a gas) is cooled, it changes into a ______________.
4. When the water (a liquid) is cooled, it changes into a ______________.
5. The state of matter of a substance may be changed by adding or removing ______________ energy.
6. *For water to change from a liquid to a solid (ice), the temperature first must drop to* ______________ *degrees F.*
7. *To change from a liquid to a gas, the temperature of water first must be raised to* ______________ *degrees F.*
8. The freezing point of water is ______________° F.
9. *The boiling point of water is* ______________° *F.*

---

3. CAN MATTER BE IDENTIFIED BY ITS APPEARANCE?

Outcomes

- Different kinds of matter may be alike in some ways and different in other ways.
- Characteristics of matter are known as *properties.*
- *The reaction of one substance with another illustrates a property of matter.*

Motivation

Exhibit four previously prepared, labeled reagent bottles containing: water, alcohol, benzene, and concentrated nitric acid. Pour each liquid into separate test tubes (large size), and set them up on a rack. Ask, "Do all the test tubes contain the same liquid?" List pupil suggestions on the board.

Development

1. Place ten drops of each liquid into a separate watch glass. Test each substance with a lighted taper to see if it will burn. Record the pupils' observations on the board. (See table.)

2. Add some copper turnings to the remaining liquid in each of the test tubes.

   NOTE: To stop the evolution of nitrogen dioxide, dilute with water.

   Record the pupils' observations.

TEST TUBE	BURNS?	FLAME COLOR	SMOKE COLOR	EFFECT ON TURNINGS
1				
2				
3				
4				

3. Lead the pupils to conclude that the test tubes contain four different liquids. Place the labeled reagent bottles in front of the corresponding test tubes and have the pupils read and record the names of the liquids.

4. Establish that the characteristics of matter are called *properties.* Ask the pupils to explain why water is included as one of the liquids. Explain the necessity for a control in an experiment.

5. *Pour about 10cc of each of the liquids into separate test tubes. Into a fifth test tube, pour 10cc salt solution. Add drops of silver nitrate to each test tube. Elicit and record the observations. The formation of the precipitate is evidence of a chemical reaction between two specific substances. Conclude that this is another property of matter.*

   CAUTION: Avoid contact with silver nitrate to prevent staining the skin.

Summary

1. Is appearance enough to identify matter? Why? ---------------
2. What methods are used to study matter? --------------------
3. The four liquids in the test tubes were: ----------, ----------, ---------- and ----------.
4. The two liquids which burned were ---------- and ----------.
5. The copper turnings reacted with the ------------------.
6. The color of the alcohol flame was ------------, and the color of the smoke was ------------.
7. The color of the benzene flame was ------------, and the color of the smoke was ------------.
8. The similarities and differences in substances depend upon their --------------------.
9. The reason for using a control in an experiment is ------------.
10. *The -------------------------- reacted to form a white solid.*
11. *The reaction of one substance with another is a ------------- of matter.*

Homework

Set up three small dishes. Place salt in the first dish, sugar in the second, and flour in the third.

1. In what ways are these substances alike?
2. Perform several experiments to find out in what ways these substances are different.
3. List the properties you have discovered for each substance.

Materials

Test tube rack
Test tubes
Labeled reagent bottles containing:
    Water
    Alcohol
    Benzene
    Concentrated nitric acid

Salt solution
Silver nitrate
Copper turnings
Wax tapers
Matches
4 watch glasses

4. WHAT ARE THE BUILDING BLOCKS OF MATTER?

Outcomes

- All matter is composed of one or more simple substances called *elements.*
- Elements cannot be separated into simpler substances by ordinary means.
- Some elements are solids, some are liquids, and some are gases.
- *There are 105 elements. Ninety occur naturally, and the remaining ones are man-made. The 105th element, Hahnium, was recently produced but has not yet been accepted by the International Union for Pure and Applied Chemistry.*

Motivation

Write the letters "A, R, T" on the board. Ask the pupils to form words using these letters (art, tar, rat). Guide the pupils to see that the letters of the alphabet are the building blocks of language. In the same manner, matter is made of simple building blocks called *elements.*

Development

1. Prior to the entrance of the class, start the Hoffman apparatus for the electrolysis of water as follows:
    a. Fill the tube with a solution containing one part sulfuric acid to twenty parts water by volume and apply 9-12 volts *direct* current from a power supply or from at least four (No. 6) 1½-volt dry cells in series.

    b. *Direct the attention of the class to the Hoffman apparatus. Explain that the tubes are filled with water and that this apparatus will help us find out which simple substances make up water. Demonstrate that electricity must be used to break up the water. Explain briefly that pure water conducts electricity poorly and that sulfuric acid has been added to make the water conduct electricity.*

    c. Elicit the observation that bubbles of gas form in the tubes and rise to the tops of the tubes. Guide the pupils to note that one tube has twice as much gas as the other.

d. Recall from the previous lesson that tests can be used to find the properties of matter. Demonstrate as follows:

1) Tap off the gas of greater volume into a small test tube and hold a burning splint near the mouth of the test tube. Have the pupils observe the "pop" or burning that occurs. Identify the gas as *hydrogen* and write the word and the symbol, H, on the board.

2) Tap off the other gas and test it with a glowing splint. Elicit the observation that the splint bursts into flames. Identify the gas as *oxygen* and write the word and the symbol, O, on the board.

e. Lead the class to conclude that water is made of hydrogen and oxygen. Explain that these are simple substances called *elements* which cannot be broken down into anything simpler by ordinary means. Establish that elements are the building blocks of matter.

2. Elicit that the elements hydrogen and oxygen are both gases. Exhibit carbon and aluminum (solid elements) and mercury (liquid). Guide the class to conclude that elements can be solids, liquids, or gases.

3. NATURAL ELEMENTS *are elements which have been discovered on earth. Ninety natural elements have been found. In recent years, man has learned how to produce new elements by changing some of the natural elements. It is possible that more new elements will be made in the future.*

Summary

1. The state of matter of water is -------------------- .
2. An -------- ------------ is used to break up water.
3. Water is broken into two ---------------.
4. The ------------------ is the name of the equipment used to break up water.
5. Water is made up of ------------ and ------------.

6. The reaction can be written as: water → ________ and ________.

7. Simple substances which are the building blocks of matter are called ______________.

8. The states of matter of elements can be __________, __________, or __________.

9. *For electricity to flow in the Hoffman Apparatus ______________ is added to the water.*

10. *There are about __________ natural elements and __________ man-made elements on earth.*

Homework

Place a teaspoon of sugar into a small saucepan and heat it over a low flame on the stove. When the sugar starts to change color, hold a cool plate above the pan. Turn off the flame. From your observations, answer the following questions:

1. The color of the sugar at the beginning is ______________.

2. The color of the solid substance remaining at the end is __________.

3. When I held the plate over the pan, I saw ____________ form on the plate.

4. The substance which remained is known as carbon. This substance is in the __________________ state.

5. The sugar is changed to ____________ and ____________.

6. ______________ is used to break up sugar.

7. This reaction can be written as: sugar → _________ and _________.

8. Water is made up of the elements ____________ and ____________.

9. The elements in sugar are __________, __________ and __________.

Materials

Hoffman apparatus
2 small test tubes
Wood splints
Sulfuric acid

Carbon
Aluminum
Mercury

5. WHAT ARE SOME PROPERTIES OF METALS?

LABORATORY LESSON

Outcomes

- Elements can be classified as metals and nonmetals.
- Metals can be identified by certain properties, such as color and luster.
- Metals conduct electricity and heat.

Motivation

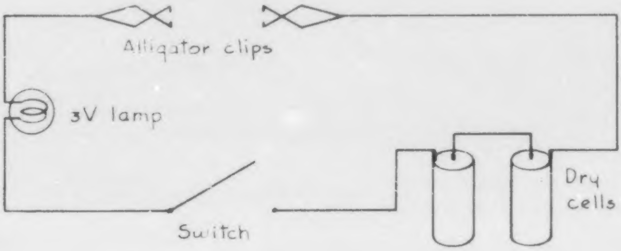
Display strips of copper, aluminum, soft iron, lead, and a sample of mercury.

Ask, "In what ways are these items alike?" Lead the pupils to conclude that these are metals and identify mercury as the only liquid metal.

Tell the class they are going to investigate some properties of metals in the laboratory lesson.

Development

1. Distribute the materials.
2. Caution the pupils about the proper use of the alcohol lamp.
3. Explain the need for the sandpaper to clear off accumulated dirt from the metal strips to determine if they have luster.
4. In advance, set up the electrical conductivity apparatus for each group, as shown in the diagram.



Homework

1. List 5 objects made of metal found in the home.
2. Name the main metallic element in each object you listed.

Materials

Strips of these metals (each 3″ long):

Soft iron	Lead	Copper
Tin	Zinc	Aluminum

Sandpaper
Alcohol lamp
Asbestos pad
Sulfur
Vial of mercury (teacher-demonstration only)

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 5

Problem: What are some properties of metallic elements?

Materials

3″ strips of metals
Sandpaper
Alcohol lamp
Asbestos pad
Electrical conductivity apparatus

Procedure and Observations

1. Write the name of each metal in the first column of the Table of Observations.
2. In the second column, state whether the metal is a solid, a liquid, or a gas.
3. Find out if each metal has a dull or a shiny surface. In case of doubt, sandpaper the strips. Record your observations in column 3.
4. Record the color of each metal in column 4.
5. Light the alcohol lamp. Hold one end of the metal strip and insert the other end into the flame.
   CAUTION: Remove the metal strip from the flame as soon as you feel the heat and place the strip on the asbestos pad. Record whether it conducts heat in column 5.

6. Insert the metal strips between the alligator clips of the electrical conductivity apparatus and close the switch. Record your observation in column 6.

TABLE OF OBSERVATIONS					
METAL	PROPERTIES				
1. Name	2. State	3. Luster	4. Color	5. Conducts Heat	6. Conducts Electricity

Conclusions

1. Characteristics of a substance are called ________________.

2. The properties of metals which we studied are:

a. ______________ c. ______________ e. ______________

b. ______________ d. ______________

3. The only metal which is a liquid at room temperature is ________________.

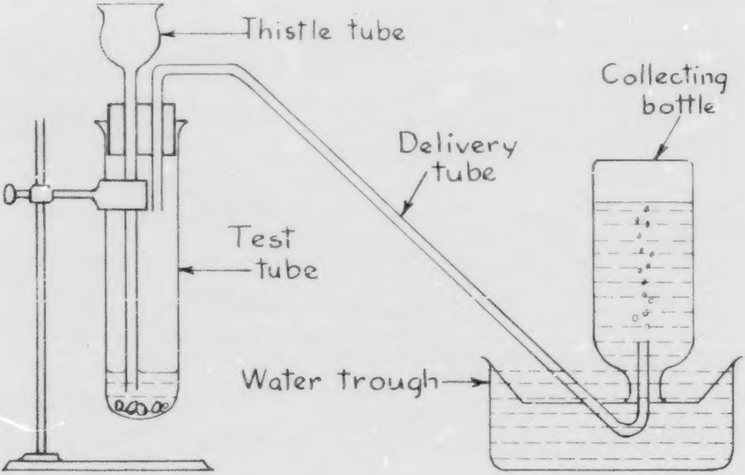
6. WHAT ARE THE PROPERTIES OF SOME NONMETALLIC ELEMENTS?

Outcomes

- Nonmetallic elements can be identified by the color, odor, and state.
- Nonmetallic elements do not have luster and do not conduct electricity.
- *Nonmetallic elements combine with metallic elements to form new substances.*

Motivation

Display the oxygen generator setup and tell the class that an element will be prepared which they are going to identify. (See diagram.)



Development

1. Prepare oxygen as follows:
    a. Fill the bottom of a large test tube with manganese dioxide *or* potassium permanganate and add about three times as much fresh hydrogen peroxide (3%).

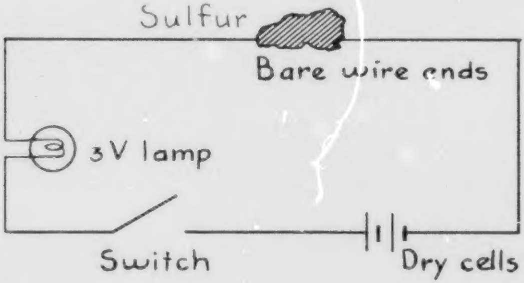
       CAUTION: Use care in handling potassium permanganate since it will stain hands and clothing.

    b. Collect two bottles of oxygen by the water displacement method.
2. Elicit the state of matter (gas) and color (colorless) from the pupils. Permit a pupil to smell the gas by wafting it towards the nose (odorless).
3. Recall the Hoffman apparatus and review the tests for hydrogen and oxygen. Use volunteers to test the samples to determine which gas is in each bottle.

4. Refer to the Table of Observations of the previous lesson and lead the class to conclude that oxygen is a nonmetallic element.

5. Display a sample of sulfur and have the pupils observe and describe its properties (yellow, solid, odorless).

6. Test the sulfur for electrical conductivity, using the following circuit:



7. Refer to the Table of Observations of the previous lesson and lead to the conclusion that sulfur is a nonmetallic element.

8. *Place a small heap of sulfur flowers on a silver spoon or a silver quarter. Hold the spoon or quarter with a pair of tongs and heat it over a small flame. Demonstrate the formation of black silver sulfide (AgS). Explain that one chemical property of the nonmetal, sulfur, is that it can combine with a metal to form a new substance.*

Summary

1. Elements can be divided into two groups: -------- and --------.
2. A nonmetal which is a gas is ----------------.
3. A nonmetal which is a solid is --------------------.
4. Nonmetals do not conduct ----------------.
5. Elements which do not have luster are -------------- (metals, nonmetals).
6. Four properties of oxygen are:

   a. --------------------
   c. --------------------
   b. --------------------
   d. --------------------

7. Four properties of sulfur are:

a. ____________________ c. ____________________

b. ____________________ d. ____________________

8. *A nonmetal will combine with a ________________ to form a new substance.*

Homework

1. Complete the following table:

Name of Element	State	Shiny/Dull	Color	Conducts Electricity	Metal/Nonmetal
Copper					
Oxygen					
Aluminum					
Sulfur					
Iron					
Hydrogen					

2. Place a silver quarter or a silver spoon in the yolk of a hard-boiled egg. Leave it in the yolk overnight. Look at the quarter or the spoon in the morning. Describe its appearance. Name the nonmetallic element in egg yolks. What new substance was formed?

Materials

Large test tube
Manganese dioxide
  or potassium permanganate
Hydrogen peroxide (3%)
Water trough
2 collecting bottles
Wood splints
2 glass plates
Sulfur flowers
Electrical conductivity
  apparatus
Silver quarter or silver spoon
Tongs

7. HOW CAN THE ELEMENTS BE ARRANGED IN A TABLE?

Outcomes

- All the elements are listed in a special order on the Periodic Table. Metallic elements are on the right side of the Periodic Table and nonmetallic elements are on the left.
- Every element has a corresponding symbol.
- *Elements listed across the Periodic Table are called a* PERIOD. *Elements listed in a column down the table are called a* GROUP.
- *Elements in a group have similar properties.*

Motivation

Ask, "How are the items arranged on the shelves in a supermarket? Would you find a can of corn on the same shelf as a box of soap?" Display a large Periodic Table and explain that elements, too, are arranged in a special order.

Development

1. Point out the letter symbols on the Periodic Table and explain that this is a form of chemistry shorthand.
2. To arrive at the symbols for the elements, these rules are followed:
   a. Use the first letter of the name of the element capitalized, as the symbol.

      Examples: Oxygen: O; Hydrogen: H; Sulfur: S; Carbon: C; Argon: A; Nitrogen: N.

   b. When the first letter has already been used, the second (or another) letter may be added to the first and shown as a small letter.

      Examples: Silicon: Si; Calcium: Ca; Chlorine: Cl; Aluminum: Al; Nickel: Ni.

   c. Some symbols are taken from the Latin name for the element.

      Examples: Copper (Cuprum): Cu; Iron (Ferrum): Fe; Lead (Plumbum): Pb; Mercury (Hydragyrum): Hg.

3. Call attention to the large chart of the Periodic Table of Elements, or distribute individual copies to the pupils. Have the pupils identify the elements with which they are now familiar. Have them write some of the elements and symbols in table form in their notebooks.

4. Explain that all known elements are listed on the table. Point out that the names and symbols for the elements are the same throughout the world.

5. Lead the pupils to realize that the metallic elements are on the right side of the table and the nonmetallic elements are on the left side. Elicit the fact that there are more metals than nonmetals.

6. *Recall the previous lesson. Have the pupils identify some of the 90 natural elements and the 15 man-made elements on the Periodic Table.*

7. *Explain that a line going across the table is called a period and a line going down the table is called a group.*

8. *Refer to the Periodic Table. Explain that elements in the same group have similar properties. Display samples of sodium chloride ($NaCl$) and potassium chloride (KCl) and elicit that these substances are similar because they are made of a metal from Group I and chlorine. Display samples of magnesium chloride ($MgCl_2$) and calcium chloride ($CaCl_2$) and note the similarity of these two substances.*

Summary

1. Refer to the Periodic Table and complete the following chart:

ELEMENT	SYMBOL	STATE	METAL OR NONMETAL
Sodium			
Oxygen			
Aluminum			
Magnesium			
Hydrogen			
Copper			
Sulphur			

2. Rearrange the listed elements according to their groups.

Homework

1. Name 10 items found in the home. Complete the following chart:

OBJECT	ONE ELEMENT IT CONTAINS	CHEMICAL SYMBOL
Ex: Penny	copper	Cu

2. Write the following in chemical symbols:
   Water = Hydrogen + Oxygen
   Sugar = Carbon + Hydrogen + Oxygen

Materials

Periodic Table (large or individual copies)

Sodium chloride	*Magnesium chloride*
Potassium chloride	*Calcium chloride*

REVIEW AND REINFORCEMENT (1—7)

NOTE: The instructor may select the most suitable exercises for review and reinforcement.

Reading Comprehension

Read these paragraphs and then answer the questions which follow:

In the Golden Age of Greece, there were many philosophers who discussed the wonders of the world. They had little knowledge of science, so they conjectured about the origins of things that exist on earth. Aristotle, one of these philosophers, observed the objects around him and decided that matter is made of four different elements. He explained that all things are made by combining these four elements.

Today we know that Aristotle was mistaken. Earth contains many natural elements. Air is a mixture of the elements in the gaseous state, and water contains hydrogen and oxygen. Fire is not matter since it does not have weight or take up space.

We have learned much since the days of the Greek philosophers, but there is still a great deal more to learn.

1. Men who thought about the origins of things were called ____________________.
2. One famous Greek thinker was named ____________________.
3. The philosopher decided that matter was made of ___________ basic elements.
4. These basic elements were:

   a) __________ b) __________ c) __________ d) __________

5. Earth contains many ____________________ elements.

Completion

1. Elements are the building blocks ________________.
2. The states of matter are:

   a) ____________ b) ____________ c) ____________

3. Matter is anything that has __________ and takes up __________.
4. Four properties of metals are:

   a) ________________ c) ________________

   b) ________________ d) ________________

5. Two examples of nonmetals are: ___________ and ___________.
6. Elements are arranged in a special order on the ______________.
7. The Hoffman apparatus is used to separate ______________ into its elements.
8. An element which supports burning is ______________________.
9. An element which pops when a burning splint is inserted into it is ___________________.

10. The only common metal which is a liquid is ----------------.

11. There are (more, fewer) metals than nonmetals.

12. An easy way to write the names of elements is to use ---------.

13. Write the symbols for the following elements:

Oxygen ----------
Hydrogen --------
Carbon ----------
Nitrogen ---------
Aluminum -------
Copper ----------
Iron ------------
Nickel ----------
Mercury --------
Sulfur ----------
Chlorine --------
Zinc -----------

14. State whether each of the following describes a solid, a liquid, or a gas:

a) Takes the shape of its container ----------------

b) Has a definite shape -------------------------

c) Takes up the entire container ------------------

Research Topics

Priestly
Lavoisier
Aristotle
Alchemists
Mendeleev

Films and Filmstrips

These may be borrowed from BAVI.

What Are Things Made Of?
World of Molecules
Materials of Our World
Symbols, Formulas, Equations
Matter and Molecules

COMPOUNDS AND MIXTURES

8. WHAT HAPPENS WHEN ELEMENTS COMBINE?

Outcomes

- Elements combine to form new substances with properties that differ from those of the original elements.
- Substances made of a combination of elements are called *compounds*.
- The name of a compound, written in symbols, is called a *formula*.

Motivation

Have pupils examine separate samples of iron filings and sulfur. Challenge the class to identify each element by its properties and list the properties on the board. Demonstrate the magnetic property of iron. Ask, "What do you think will happen if we mix these elements together?"

Development

1. Thoroughly mix a small portion of iron filings with an excess amount of sulfur. Call on pupils to separate the iron filings from the sulfur with a magnet. Guide the pupils to conclude that mixing iron and sulfur together does not result in any changes in the properties of the elements.

2. Fill ¼ of a small pyrex test tube with the iron-sulfur mixture. Hold the test tube with a test tube holder and heat the mixture gently and evenly. When the contents glow, remove the tube from the heat. Call attention to the glow as an indication that a chemical action is taking place.

3. Immerse the hot test tube in a beaker of cold water to crack the test tube. If it does not crack, wrap the test tube in a paper towel and break it with a hammer. Elicit the description of the appearance of the new substance. Invite pupils to test the substance with a magnet to determine its properties now.

4. Compare this set of properties with those of the original elements. Guide the class to conclude that a new substance with new properties has been formed. Define *compound:* a substance which consists of two or more elements chemically combined.

5. Write the word and symbol equations for the reaction on the board: Iron + sulfur iron sulfide
   $Fe + S$ FeS

6. Identify the symbols for the compond FeS. Explain that this is called a *formula.*

Summary

1. Elements combine to form ____________________.
2. The properties of compounds are (different from, the same as) the properties of the original elements.
3. The name of the compound, written in symbols, is ____________.
4. The formula for a compound tells which ________________ are contained in the compound.
5. Most of the substances we use are (compounds, elements).

Homework

List the names and symbols of the elements found in each of the following compound formulas:

H_2O = Water ex. →	hydrogen (H) & oxygen (O)
NaCl = Sodium chloride, table salt	
H_2O_2 = Hydrogen peroxide	
$NaHCO_3$ = Sodium carbonate, baking soda	
NaOH = Sodium hydroxide, lye	
NH_4OH = ammonium hydroxide, ammonia	
$C_{12}H_{22}O_{11}$ = cane sugar	

Materials

Iron filings
Finely crushed sulfur powder
Magnet
Small test tube
Beaker
Bunsen burner
Test tube holder

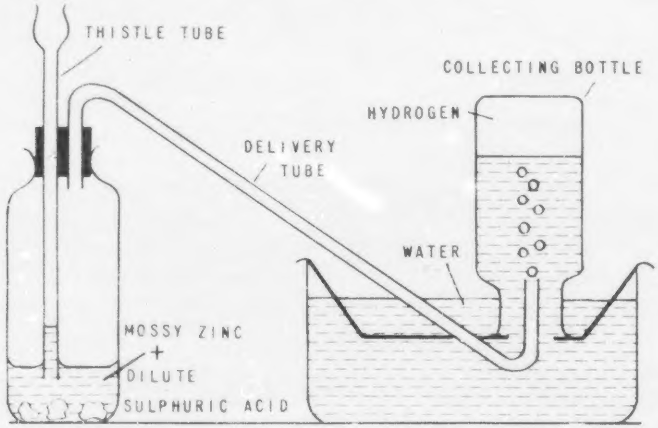
9. WHAT HAPPENS TO ELEMENTS WHEN THEY FORM COMPOUNDS?

Outcomes

- Elements do not retain their original properties when they combine to form compounds.
- Compounds can be broken down into their original elements.
- *One metal may replace another metal in a compound. This reaction is called a* SINGLE REPLACEMENT REACTION.
- DECOMPOSITION *is the breaking down of a compound into its elements.*

Motivation

Set up the hydrogen generator, as shown in the diagram. Explain to the class that you are going to prepare an element.



Fill 3 bottles with water and invert them in the trough, one at a time. Before inverting each bottle, cover it with a glass plate and then remove the plate after the bottle is submerged in the trough. Place the free end of the delivery tube in the bottle and allow the gas to fill the bottle by water displacement. Slip the glass plate under the mouth of the bottle, remove the bottle, and set it upright on the demonstration table. Similarly, fill the other two bottles with hydrogen.

WARNINGS: Discard the first bottle of gas because it contains a mixture of hydrogen and oxygen which is explosive. Keep the glass plates over the 2 remaining bottles to prevent the escape of gas.

Development

1. Identify the parts of the generator. Write the symbol for zinc (Zn) and the formula for sulfuric acid (H_2SO_4) on the board. Elicit the name of the gaseous element, hydrogen, being formed.
2. Guide the pupils to understand the water displacement technique by pointing out that the hydrogen gas pushes the water out of the collecting bottle.

3. Remove the glass plate from the second bottle. Apply a burning splint to the mouth of the bottle to show that the gas inside is hydrogen.

4. Display the third bottle of hydrogen. Elicit the properties of hydrogen from the class: gas, clear, colorless. Hold a burning splint to the mouth of the bottle and have the pupils observe what happens when the hydrogen burns in the bottle.

5. Ask the pupils to observe the cloudy appearance of the bottle and elicit that water was produced when the hydrogen burned. Lead the class to conclude that when the hydrogen burned, it combined with oxygen from the air around the bottle.

6. Write the word and symbol equations for the reaction on the board:

   hydrogen + oxygen → water

   $2H_2 + O_2 \rightarrow 2H_2O$

7. Elicit the properties of hydrogen, oxygen, and water from the class and list them on the board. Have the class conclude that elements do not retain their original properties when they combine to form compounds.

8. Recall the Hoffman apparatus. Guide the pupils to write the word and symbol equations for this reaction:

   water → hydrogen + oxygen

   $2H_2O \rightarrow 2H_2 + O_2$

   Have the pupils conclude that a compound can be broken down into its original elements.

   NOTE: Do not stress the balancing of equations.

9. *Refer to the hydrogen generator. Lead the pupils to realize that the hydrogen gas was released from the sulfuric acid and the zinc took the place of the hydrogen in the compound:*

   $Zn + H_2SO_4 \rightarrow Zn\ SO_4 + H_2$

   Identify this type of reaction as a SINGLE REPLACEMENT.

10. *Point to the equation for the breaking down of water in the Hoffman apparatus. Identify this as a* DECOMPOSITION REACTION.

Summary

1. The properties of hydrogen and oxygen are (different from, the same as) the properties of water.

2. The properties of the combining elements are (different from, the same as) the properties of the compound.

3. Compounds can be broken down into their ----------------.

4. The symbol equation for the formation of water is:

   ----------- + ----------- → -----------

5. The symbol equation for the breaking down of water is:

   ----------- + ----------- → -----------

6. *The hydrogen in the sulfuric acid was replaced by* -----------.

7. *This type of chemical reaction is called a* --------- --------- *reaction.*

8. *A reaction in which a compound is broken down into its elements is called a* ------------------- *reaction.*

Homework

1. Complete the following equations:

   a. NaCl → ----- + -----
   b. HCl → ----- + -----
   c. CO_2 → ----- + -----
   d. ZnS → ----- + -----
   e. Fe_2O_3 → ----- + -----

2. *Complete the following equations and state whether the reaction in each is a single replacement.*

   a. 2HgO → ---- + ----
   b. Pb + H_2SO_4 → ---- + ----
   c. Na + HCl → ---- + ----
   d. 2MgO → ---- + ----

Materials

Hydrogen generator
Mossy zinc
Dilute sulfuric acid
Water trough
Collecting bottles
Glass plates
Wood splints

10. WHAT HAPPENS TO THE WEIGHT OF AN ELEMENT WHEN IT IS BURNED?

LABORATORY LESSON

Outcomes

- Oxidation is a reaction in which a material combines with oxygen.
- When an element is burned, or oxidized, there is a gain in weight.

Motivation

Have the pupils suggest hypotheses regarding what might happen to the weight of steel wool when it is burned. List these suggestions on the chalkboard and refer to them at the end of the laboratory lesson.

Development

1. Demonstrate the use of the triple-beam balance.
2. Demonstrate the proper method for burning the steel wool. Hold the steel wool over the asbestos pad to catch any falling particles.
3. Distribute the materials to the laboratory groups.

Homework

Place a piece of steel wool on the bottom of an empty drinking glass. Invert the glass into a bowl of water. Let the setup stand overnight. Examine it in the morning.

1. What has happened to the steel wool? Why?
2. What has happened to the level of water in the glass? Why?
3. What term is used to denote the change in the steel wool?
4. How does this experiment differ from the burning of the steel wool in the laboratory lesson?

Materials

Triple-beam balance
Fine steel wool (#000) loosely packed
Tongs
Asbestos pad
Alcohol lamp

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 10

Problem: What happens to the weight of steel wool when it burns?

Materials

Fine steel wool, loosely packed	Tongs
Asbestos square	Alcohol lamp
	Triple-beam balance

Procedure and Observations

1. Weigh asbestos pad and record weight in Column 1 of suggested table:

TABLE OF WEIGHTS					
ASBESTOS	STEEL WOOL & ASBESTOS	STEEL WOOL	STEEL WOOL & ASBESTOS AFTER HEATING	STEEL WOOL ALONE, AFTER HEATING	+ OR − CHANGE

2. Place steel wool on the asbestos pad and weigh them. Enter the combined weight in Column 2.

3. Find the weight of the steel wool alone by subtracting the weight in Column 1 from that in Column 2. Record the result in Column 3.
Example: weight of asbestos pad and steel wool ________________
− weight of asbestos pad alone ________________________
= weight of steel wool alone ________________________

4. Remove the asbestos pad to the table.
Place the burner on the pad and carefully light the burner.

5. Grasp the steel wool with the tongs and hold it in the flame until it glows.

6. Remove the alcohol lamp from beneath the glowing steel wool. Blow on the steel wool to keep it glowing as long as you can.
NOTE: Hold the burning steel wool over the pad to catch any falling particles.

7. Place the burned steel wool on the pad along with the fallen particles and weigh the pad and the steel wool. Record the combined weight in Column 4.

8. Subtract the weight of the asbestos pad in Column 1 from the weight entered in Column 4 Record the weight of the burned steel wool in Column 5.
9. Compare the weight in Column 5 with that in Column 3 by subtracting the smaller number from the larger number. Record the change in weight, if any, in Column 6. If weight was lost, place a minus sign (−) in front of the change in weight. If weight was gained, use a plus (+) sign.
10. If time permits, repeat the experiment with another sample of steel wool.

Conclusions

1. The weight of the steel wool (increased, decreased, did not change) after it was burned.
2. *Oxidation* is a reaction in which a material combines with ________________.
3. When the steel wool was burned, it combined with ____________________.
4. The change in weight was due to ____________________.
5. When the steel wool was burned, a new ________________ was formed.
6. The main element in steel wool is __________________.
7. Iron plus oxygen makes the compound, ________________ ________________.
8. This reaction, written in symbols, is __________ + __________ → __________.

---

11. WHY DOES A COMPOUND HAVE A DEFINITE FORMULA?

Outcomes

- Many compounds are made up of metallic elements combined with nonmetallic elements.
- The smallest part of a compound which still has the properties of that compound is called a *molecule*.
- Elements combine in definite proportions to form compounds.
- *The combining ability of an element is called* VALENCE.

Motivation

Ask pupils to think of the tiniest drop of water possible, one so tiny that it cannot be seen by the human eye. Establish that this drop is still water. Its formula is H_2O, and it still has the properties of water. Lead the class to realize that if this drop of water is broken down further, it becomes hydrogen and oxygen, not water. Identify this smallest amount of water as one *molecule* of water.

Development

1. Define *molecule:* the smallest part of a substance with the properties of that substance.

2. Display a sample of iron filings and sulfur. Recall that heating produces the compound, iron sulfide. Elicit that iron is a *metal* and sulfur is a *nonmetal.*

3. Write the names and formulas for other compounds on the board: $NaCl$, MnO_2, $NaOH$, ZnS, PbO. Have pupils name the elements in each compound and lead them to conclude that each compound consists of a metal combined with a nonmetal.

4. Refer to the previous demonstration of combining iron and sulfur. Inform the pupils that one part iron was combined with two parts of sulfur. Tell the class that this time you are going to use two parts iron to one part sulfur. Elicit the hypothesis about what might happen and perform the experiment. After the test tube is cracked, have pupils test the mass with a magnet. Elicit the observation that some iron is left uncombined with sulfur.

   Similarly, establish that if you had used three parts sulfur to one part iron, some sulfur would be left uncombined. Lead to the conclusion that elements combine in definite proportions to form compounds.

   Refer to the compounds listed on the board. Point out that one unit of oxygen combines with one unit of lead, while it takes two units of oxygen to combine with one unit of manganese. Identify the combining ability of an element as its valence.

   NOTE: Valence will be explained further in the lessons on atomic structure.

Summary

1. The smallest part of a substance having the properties of that substance is called a --------------------.
2. H_2O represents one ------------------ of water.
3. H_2 and O_2 are the ----------------- in water.
4. Some compounds consist of a -------- combined with a --------.
5. Identify the *metal* and *nonmetal* in each of these compounds:

Fe_2O_3 -------- --------
HgO -------- --------
MgO -------- --------
PbS -------- --------
HCl -------- --------

6. One part iron combines with -------------- parts sulfur to form iron sulfide.
7. Elements combine in definite -------------- to form compounds.
8. *The combining ability of an element is called its* ---------------.

Homework

Complete the following chart by combining the metals and the nonmetals and writing the formulas for the compounds in the boxes. Next to each formula, write the name for the compound.

FORMING COMPOUNDS						
METAL.	WITH OXYGEN	NAME OF COMPOUND	WITH SULFUR	NAME OF COMPOUND	WITH CHLORINE	NAME OF COMPOUND
Fe	FeO	iron oxide	FeS	iron sulfide	$FeCl$	
Mg						
Hg						
Zn						

12. WHAT ARE THE PROPERTIES OF A COMMON COMPOUND?

Outcomes

- Carbon dioxide is a colorless, odorless gas which does not support combustion.
- Carbon dioxide is heavier than air.
- *Oxidation of carbon can produce carbon dioxide.*

Motivation

Display a generator similar to that used to prepare hydrogen. Substitute marble chips for the mossy zinc. Review how this apparatus was used before. Elicit that acid will be poured through the thistle tube into the bottle and a gas will evolve. Review the water-displacement method of collection. State that the gas to be produced is a common substance which is always around us.

Development

1. Gently pour diluted hydrochloric acid into the generator a[illegible] place the delivery tube directly into an eight-ounce colle[illegible] bottle which is held right-side up. Collect three bottles of gas by air displacement and cover the bottles with glass plates.
2. Elicit the properties of the substance and list them on the board: gas, colorless, odorless.
3. Have pupils discuss the disadvantages of the air-displacement method of collection as compared with the water-displacement method. Explain that nearly pure gas is obtainable by water-displacement and we can tell accurately when the bottle is full.
4. Ask, "Why is it possible to collect this gas by air displacement?" Guide pupils to conclude that the gas is heavier than air.
5. Test one bottle of gas with both burning and glowing wood splints. Establish that the gas is neither hydrogen nor oxygen.
6. Place a small candle in the center of a large jar or beaker, light the candle, and permit a pupil to pour the gas from the second

bottle over the burning candle. Elicit the fact that this gas does not support combustion. Add this to the list of properties.

7. Identify the gas as carbon dioxide and write the name and formula, CO_2, on the board.

   NOTE: In steps 8, 9, and 10 make sure to set up controls to show that it is the carbon dioxide and no other material that turns the limewater milky.

8. Demonstrate a test for carbon dioxide as follows:

   Mix the third bottle of gas with 10ml of limewater and shake it. Have pupils observe the milky appearance of the substance formed.

9. Pour one inch of limewater into a test tube and have a pupil exhale into the test tube through a straw. Exhibit the milky substance which forms, and lead the pupils to conclude that exhaled air contains carbon dioxide which is produced by the body.

10. *Ignite a piece of paper and invert a beaker over it. When the flame goes out, remove the beaker and cover it quickly with a glass plate. Add limewater to the beaker and shake it. Explain that paper contains carbon, and elicit that the oxidation of a carbon product produces carbon dioxide.*

11. *Explain briefly that plants take in oxygen and give off carbon dioxide in the process of respiration. In the process of photosynthesis, or food-making, the plants give off carbon dioxide and give off oxygen.*

Summary

1. Four properties of carbon dioxide are:

   a. ___________ b. ___________ c. ___________ d. ___________

2. Carbon dioxide may be collected by ______________ displacement or by ______________ displacement.

3. Carbon dioxide is (heavier, lighter) than air.

4. The formula for carbon dioxide is ______________.

5. Carbon dioxide turns ______________ milky.

6. Exhaled air contains ______________.

7. *When a carbon product is oxidized, ______________ is produced.*

8. *In respiration, plants take in __________ and give off __________.*

9. *For photosynthesis, plants take in __________________ and give off ________________.*

Homework

1. Shake a *half-filled*, warm bottle of soda. Observe the gas bubbles rising in the liquid. What gas is contained in soda?
2. Open a bottle of soda and half fill a glass with soda. Sip some soda; then set the glass aside for several hours. Sip some of the remaining soda. Describe the difference in the taste of the soda after it has been open to the air for awhile. Why does the soda taste different?
3. Why are carbon dioxide fire extinguishers used to put out fires?

Materials

Generator bottle
Thistle tube
Delivery tube
Marble chips
Paper
3 collecting bottles
Dilute hydrochloric acid
Glass plates
Water trough
Wood splints
Candle
Limewater
Test tube
Drinking straw
Beaker

13. HOW DOES A CHEMICAL CHANGE DIFFER FROM A PHYSICAL CHANGE?

LABORATORY LESSON

Outcomes

- A physical change is a change in size, shape, or state of the original substance.
- A chemical change results in the formation of a new substance with a new set of properties.

Motivation

Briefly review Laboratory Lessons 2 and 10. Guide pupils to realize that changing ice to water and then to water vapor are examples of *physical change*, since the formula (H_2O) does not change and only the state is changed. Recall the oxidation of steel wool results in the formation of a new substance, iron oxide, with a new set of properties. Explain that this is an example of a *chemical change*. Tell the pupils that they are going to identify different kinds of physical and chemical changes in this laboratory lesson.

Development

1. Distribute the materials for the laboratory lesson.
2. Instruct pupils about the proper method of burning a wood splint and handling acid.

Homework

1. Next to each of the following, place the letter "P" if it is an example of a physical change or "C" if it is a chemical change.
   a. Tearing a piece of paper --------
   b. Melting a lump of sugar in a cup of coffee --------
   c. Breaking a rubber band --------
   d. Changing water into hydrogen and oxygen in the Hoffman apparatus --------
   e. Toasting a marshmallow --------
2. List 3 examples of *physical* change occurring in the home.
3. List 3 examples of *chemical* change occurring in the home.

Materials

Wood splints
Small pieces of chalk
3 test tubes
Test tube rack
Forceps or tongs
Alcohol lamp

Mortar and pestle
Dilute hydrochloric acid
Magnesium sulfate solution
Barium chloride solution
Asbestos square

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 13

Problem: How does a chemical change differ from a physical change?

Materials

2 wood splints
Small pieces of chalk
3 test tubes
Test tube rack
Forceps or tongs
Asbestos square
Magnesium sulfate solution
Barium chloride solution
Alcohol lamp
Mortar and pestle

Procedure and Observations

1. What are the characteristics of chalk? ____________________

2. Use the mortar and pestle to grind up a piece of chalk.

   Are the small particles still chalk? How can you tell? ____________________

   Is this a physical change or a chemical change? ____________________

3. Place two small pieces of chalk into a test tube. Add one inch of dilute hydrochloric acid.

   What do you observe? ____________________

   Is this a physical change or a chemical change? ____________________

4. Break one wood splint into several pieces.

   Are the pieces still wood? ____________________

   Is this a physical change or a chemical change? ____________________

5. Hold a wood splint with the forceps. Set the alcohol lamp on the asbestos square and ask your teacher to light it. Burn the wood splint. Compare the ash to the pieces of wood splint. How did the wood change when it was burned? ____________________

   Is this a chemical change or a physical change? ____________________

6. Pour ½ inch of magnesium sulfate solution into a test tube. Add ½ inch of barium chloride solution.

   Before mixing, the magnesium sulfate was (clear, cloudy) and the barium chloride was (clear, cloudy).

   After mixing, the solution is (clear, cloudy).

   Is this a chemical change or a physical change? ____________________

Conclusions

1. Complete the table:

SUBSTANCE	METHOD OF CHANGE	NEW APPEARANCE	CHEMICAL OR PHYSICAL CHANGE
Chalk	breaking		
Chalk	react with HCl		
Wood	breaking		
Wood	burning		
$MgSO_4$	react with $BaCl_2$		

2. A physical change is a change in ----------, ----------, or ----------.

3. A chemical change results in the formation of a ------------.

4. The properties of the substance which results from a chemical change are (the same as, different from) the properties of the original substance.

14. DOES CHEMICAL CHANGE INVOLVE A CHANGE IN ENERGY?

Outcomes

- In a chemical change, energy is either released or absorbed.
- When heat energy is released, the reaction is called *exothermic*.
- When heat energy is absorbed, the reaction is called *endothermic*.

Motivation

Have a pupil locate magnesium on the Periodic Table. Exhibit a strip of magnesium ribbon. Elicit its metallic properties from the class (solid, silvery, lustrous). Hold the strip with tongs, ignite it with a bunsen burner, and permit it to burn in air. *Caution pupils not to look* *directly at the bright light.* Exhibit the white powder that forms and ask, "Is this a physical change or a chemical change? Why?"

Development

1. Guide the pupils to conclude that a chemical change took place.

2. Establish that this is a chemical change and that a new substance with a new set of properties was formed.

3. On the board, write equations using both names and symbols for the reactions:

   Magnesium + Oxygen → Magnesium oxide

   $2\ Mg + O_2 \rightarrow 2\ MgO$

4. Elicit that heat and light energy were given off during this reaction. Rewrite the equation as follows:

   $2\ Mg + O_2 \rightarrow 2\ MgO +$ Heat + Light

   (Metal) + (Nonmetal) → (New substance) + Energy

5. Add a few pieces of mossy zinc to 5-10ml of dilute hydrochloric acid in a test tube. Elicit that the bubbling indicates a chemical reaction. Invite a pupil to feel the test tube and permit him to report that the test tube feels warm. Test for hydrogen gas (burning splint) and confirm that a new compound is formed.

   Lead the pupils to conclude that this is a chemical change in which only heat energy is given off.

6. *On the board, write equations using both names and symbols for this reaction:*

   Zinc + Hydrochloric acid → Zinc chloride + Hydrogen + Heat

   $Zn + 2\ HCl \rightarrow Zn\ Cl_2 + H_2 +$ Heat

   State that a chemical change in which heat energy is given off is called an *exothermic reaction.*

7. Place about ½ teaspoon of mercuric oxide into a pyrex test tube. Heat it strongly with a bunsen burner for a few minutes. While heating the test tube, use a glowing splint to test the gas which is being liberated. Remove the test tube from the heat and ask pupils to examine the deposit which formed on the inside of the upper part of the test tube.

8. Have the pupils identify the gas as oxygen and the deposit inside the test tube as mercury.

9. Lead to the conclusion that the orange-colored substance in the tube contained mercury and oxygen. Identify it as mercuric oxide.

10. *Elicit that heat energy is necessary to change mercuric oxide* to mercury and oxygen. Write, on the board, the word and symbol equations for the reaction.

$$\text{Mercuric oxide} + \text{Heat} \rightarrow \text{Mercury} + \text{Oxygen}$$
$$2\,HgO + \text{Heat} \rightarrow 2\,Hg \quad O_2$$

11. Guide the pupils to conclude that in some chemical changes heat energy is absorbed.

12. State that a chemical change in which heat energy is absorbed is called an *endothermic reaction.*

Summary

1. When magnesium burns, ---------- and ---------- energy are given off.
2. When zinc reacts with hydrochloric acid, ------------ energy is given off.
3. To change mercuric oxide into mercury and oxygen, ------------ energy must be absorbed.
4. In a chemical change, ---------- is either ---------- or ----------.
5. If heat energy is released, the reaction is ---------------.
6. If heat energy is absorbed, the reaction is ---------------.

Homework

1 Complete the table:

Reaction	Energy Released or Absorbed	Form of Energy
Burning paper		
Hoffman apparatus		
Burning steel wool		
$2H_2 + O_2 \rightarrow 2H_2O$		

2. Examine a flashbulb. What metal is inside the bulb? What happens when the metal burns? What is the appearance of the metal after the flashbulb is used?

Materials

Strip of magnesium	Mossy zinc
Tongs	Mercuric oxide
Bunsen burner	2 pyrex test tubes
Dilute hydrochloric acid	Wood splints

15. HOW DO MIXTURES DIFFER FROM COMPOUNDS?

Outcomes

- A mixture consists of two or more substances, each of which retains its own properties.
- The formation of a mixture involves a physical change. The formation of a compound involves a chemical change.
- In a mixture, there is no definite ratio between the amounts of each substance; the elements in a compound are in a fixed ratio.
- A formula can be written for a compound but cannot be written for a mixture.

Motivation

Recall from Lesson 8 that stirring the iron filings with the sulfur did not change the properties of the elements; when the mixture was heated, a compound, iron sulfide, was formed. Refer to Lesson 11 and guide pupils to recall that a specific amount of iron was combined with a specific amount of sulfur to form the compound, iron sulfide. Ask, "What changes are involved in the following demonstrations?"

Development

1. To demonstrate a physical change, add some sugar to a 250ml beaker of water and stir to dissolve the sugar. Permit a volunteer

to taste the solution and elicit that it tastes sweet. Place a small amount of the solution in an evaporating dish and evaporate the water over an alcohol lamp. Indicate the sugar which remains in the dish and guide the pupils to realize that mixing sugar in water does not change its properties. Define the term mixture, and lead to the conclusion that a *mixture* involves a *physical change*.

2. To demonstrate a chemical change, place 10gm sugar into a 400ml beaker. Place the beaker on an asbestos square. Slowly add 15-20ml concentrated sulfuric acid. Stir with a glass rod until a viscous mass results. Draw the attention of the students to the char and the steam. Guide the pupils to realize that a *chemical change* has taken place and a new substance has been formed. Lead to the conclusion that the formation of a substance involves a *chemical change*.

   CAUTION: Do not handle the char since some sulfuric acid may be left uncombined and may burn the skin. Exercise care in using concentrated sulfuric acid (see *Safety Manual*).

3. From the activities suggested, the pupils learn how a mixture differs from a compound. They should conclude that in a mixture, the parts may be mixed in any amounts. In a compound, the parts can only combine in definite proportions.

4. Ask, "What is the formula for the mixture of iron and sulfur?" Elicit that a formula cannot be written for a mixture. Ask, "What is the formula for the compound, iron sulfide?" Elicit the formula, FeS, and explain that the formula for a compound tells us what elements it contains and the number of units of each element, i.e., one atom of iron and one atom of sulfur.

Summary

1. When iron filings are stirred with sulfur, a ----------------- change occurs.
2. Iron filings stirred with sulfur are an example of a (mixture, compound).
3. When sugar is dissolved in water, a ------------ change occurs.
4. Sugar dissolved in water is an example of a (mixture, compound).
5. When a mixture of iron and sulfur is heated, a ---------------- change occurs.

6. Iron sulfide is an example of a (mixture, compound).
7. When sugar reacts with concentrated sulfuric acid, a ---------- change occurs.
8. In a mixture, there (is, isn't) a definite ratio between the amounts of each substance.
9. The elements in a compound (are, are not) in a fixed ratio.
10. A formula can be written for a (mixture, compound).
11. A formula tells what ---------- are contained in the compound.
12. A formula tells the number of units of each ----------- in the compound.

Homework

1. List three differences between a compound and a mixture.
2. Explain why air is a mixture.
3. Explain why a cup of instant coffee is a mixture.
4. Name the elements and the number of units of each element in the following compounds:

H_2O	
CO_2	
$C_6H_{12}O_6$	
HCl	
H_2SO_4	
HgO	
MgO	
Fe_2O_3	

Materials

Sugar
Ring
Ring stand
Wire gauge

10gms sugar
400ml beaker
250ml beaker
Alcohol lamps

20cc conc sulfuric acid
Asbestos square
Glass stirring rod
Evaporating dish

16. HOW CAN WE SEPARATE THE PARTS OF A MIXTURE?

LABORATORY LESSON

Outcomes

- Physical changes may be used to separate parts of a mixture.
- Some physical changes which are used to separate parts of a mixture are: solution, filtration, evaporation, and magnetic attraction.
- The type of physical change used depends on the nature of the mixture.

Motivation

Explain that, in this laboratory lesson, the pupils are to separate and identify the parts of an unknown mixture.

Development

1. Briefly discuss some physical changes which can be used to separate the parts of a mixture. Define each term and demonstrate the technique:
   a. Magnetic separation
   b. Solution (mix with water)
   c. Filtration (show method of folding filter paper and insertion into funnel)
   d. Evaporation (use evaporating dish or watch glass)
2. Distribute materials and guide the pupils in performing the activity.

Homework

A boy spilled a cup of sugar into a pile of sand at the beach. Write up an experiment to show how he can get the sugar back. Use the proper experiment form: Problem, Materials, Procedures and Observations, Conclusions.

Materials

Mixture (sand, salt, iron filings)
Evaporating dish or watch glass
Asbestos square
Ring stand and ring
Test tubes in rack
Alcohol lamp
Stirring rod
Filter paper
Hand lens
Magnet
Beaker
Funnel
Wire gauze
Tongs

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 16

Problem: How can we separate the parts of a mixture?

Materials

Magnet
Funnel
Beaker
Tongs
2 test tubes
Test tube rack
Hand lens
Wire gauze
Alcohol lamp
Ring stand and ring
Filter paper
Asbestos square
Stirring rod
Unknown substance (in test tube)
Evaporating dish or watch glass

Procedures and Observations

1. Use the hand lens to examine the unknown substance in the test tube. Is it a mixture or a compound? ______________ How do you know? ______________

2. Use the magnet to try to remove a part of the unknown substance. What did the magnet remove? ______________ Is this a physical or a chemical change? ______________

3. Pour one inch of the remaining unknown substance into a test tube and add one inch of water. Stir the mixture. What happens? ________________ This type of physical change is called ________________.

4. Fold the filter paper and place it in the funnel. Place the funnel in the opening of a clean test tube and pour the mixture into the funnel.

   Describe the material in the test tube. ________________ What is left on the filter paper? ____________ This type of physical change is called ____________.

5. Pour a small amount of the liquid from the test tube into the evaporating dish or watch glass. Place the alcohol lamp on the asbestos square under the ring. Adjust the ring to a height of one inch above the alcohol lamp. Place the wire gauze on the ring and put the evaporating dish or watch glass on the wire gauze. Ask your teacher to light the alcohol lamp and heat until the liquid is gone. Cap the alcohol lamp and carefully examine the remains in the dish or glass.

   Describe the material that remains. ____________________________________

   Touch the tip of your finger to the material and touch your finger to the tip of your tongue. What does it taste like? ____________________

   This type of physical change is called ______________________.

Conclusions

1. The parts of the unknown substance are:

   a. ______________ b. ______________ c. ______________

2. The unknown substance is a (mixture, compound).
3. A magnet was used to ________________.
4. Solution was used to ________________.
5. Filtration was used to ________________.
6. Evaporation was used to ______________.
7. (Physical, chemical) changes may be used to separate the parts of a mixture.

REVIEW AND REINFORCEMENT (8—16)

Multiple Choice

1. Elements combine to form
   a) mixtures b) formulas c) equations d) compounds
2. The properties of a compound are
   a) different from the properties of the combining elements
   b) the same as those of the combining elements
   c) the same as one of the combining elements
3. The name of the compound, written in symbols, is called
   a) an equation b) an element c) a formula d) a reaction

4. The symbol equation for the formation of water is
   a) $H_2O \rightarrow H_2 + O_2$ b) $H + O \rightarrow HO$
   c) $HO_2 \rightarrow H + 2O$ d) $2H_2 + O_2 \rightarrow 2H_2O$

5. When steel wool is burned, its weight
   a) increases b) decreases c) does not change

6. Oxidation is a reaction in which a material combines with
   a) oxygen b) hydrogen c) water

7. The symbol equation for burning steel wool is
   a) $Fe + H_2 \rightarrow FeH_2$ b) $4Fe + 3O_2O_3$ c) $I + O_2 \rightarrow IO_2$

8. The smallest part of a substance which still has the properties of that substance is called
   a) a formula b) an element c) a molecule
   d) a compound

9. Many compounds consist of
   a) two metals combined b) two or more nonmetals combined
   c) metals combined with nonmetals

10. Elements combine in definite proportions to form
    a) molecules b) mixtures c) compounds

11. The formula for carbon dioxide is
    a) C_2O b) CO c) CO_2

12. A good test for carbon dioxide is one involving
    a) limewater b) a burning splint c) a glowing splint

13. Carbon dioxide may be collected
    a) only by air displacement b) only by water displacement
    c) by air displacement or by water displacement

14. Carbon dioxide may be used in fire extinguishers because
    a) it is heavier than air b) it is lighter than air
    c) it helps things burn

15. A physical change results in
    a) the formation of a new substance b) no change in chemical properties c) a change in color

16. An example of a chemical change is
a) dissolving sugar   b) tearing paper   c) burning wood

17. In a chemical change
a) energy is either released or absorbed   b) no energy change occurs   c) heat energy is always released

18. When magnesium burns
a) heat energy is absorbed   b) heat energy is released
c) heat and light are given off

19. For the reaction $2HgO - 2Hg + O_2$
a) HgO must be heated   b) heat energy is given off
c) no energy change occurs

20. When iron filings are mixed with sulfur
a) no change occurs   b) a chemical compound is formed
c) a physical change occurs

21. Sugar dissolved in water is an example of
a) a mixture   b) a compound   c) an element

22. When a mixture of iron and sulfur is heated
a) the compound, iron sulfide, is formed   b) a new mixture is formed   c) no change takes place

23. A formula can be written for
a) a mixture   b) an element   c) a compound

24. One method for separating the parts of a mixture is
a) oxidation   b) stirring   c) filtration

25. To separate the parts of a mixture we use
a) physical changes   b) chemical changes   c) both physical and chemical changes

Audio-Visual Material

Films (BAVI)

Matter and Energy   *Fire and Oxidation*   *Simple Changes in Matter*

Filmstrips (BAVI)

Elements, Compounds, Mixtures
Symbols, Formulas, Equations
The World's Matter Supply
What Is Matter?

ATOMIC THEORY

17. CAN MOLECULES BE BROKEN DOWN INTO SMALLER PARTS?

Outcomes

- Molecules of a compound are composed of atoms of elements.
- The atom is the basic unit of all matter.

Motivation

In advance of the lesson, prepare an empty matchbox into which a small marble or piece of chalk is placed. Display the matchbox to the class and ask for volunteers to describe the object inside the box, without opening the box. List the descriptions on the chalkboard and permit the pupils to guess the name of each object described. Exhibit the marble or chalk to the class and point out the accuracy of their descriptions. Ask, "How were you able to describe an object without seeing it?" Explain that, similarly, scientists have determined there is something smaller than a molecule.

Development

1. Relate that the first person to speculate that matter is made of tiny particles was Democritus, a Greek teacher, in 4BC. Democritus named these particles *atoms* and described them as small, hard, invisible particles which could not be broken into anything simpler.

2. In 1803, John Dalton published his theory which reinforced the ideas of Democritus as follows:
   a. All elements are made up of small, invisible particles called *atoms.*
   b. Atoms of the same element are alike but are different from atoms of all other elements.
   c. Atoms are solid, indivisible particles.
3. Use styrofoam balls or a flannel board and cutouts to demonstrate molecules of some common compounds. Write the formulas for the compounds on the chalkboard. Permit the pupils to assist in making the molecules. For example: $NaCl$, $NaOH$, H_2O, CO_2, HCl, H_2SO_4, $AgNO_3$.
4. Elicit new definitions for the term *molecule,* e.g., two or more atoms; the smallest unit of a compound that retains the properties of that compound.
5. Drill the class in naming the elements in common compounds and stating the number of atoms of each element in the compound.
6. Refer to Dalton's theory and establish that the evidence shows 2a and 2b are still true. Guide the class to realize that we have since proven that atoms are divisible. Explain that the parts of an atom will be discussed in the next lesson.

Summary

1. Scientists learn about things we cannot see by ________________.
2. The first person to use the word *atom* was ____________________.
3. The three parts of Dalton's theory are: a. ____________________
   b. __________________________ c. __________________________.
4. The part of Dalton's theory which has been proven false is ______
   ______________________________.
5. A molecule consists of two or more __________________________.
6. The basic unit of all matter is the __________________________.

Homework

1. For each of the compounds listed in the table, write the names of the elements and the number of atoms in each element.

COMPOUND	ELEMENT	NO. OF ATOMS	ELEMENT	NO. OF ATOMS	ELEMENT	NO. OF ATOMS
H_2O	Hydrogen	2	Oxygen	1		
NH_4OH						
$C_6H_{12}O_6$						
MgO						
HgO						
Fe_2O_3						

2. Report on these scientists who have worked in the field of atomic energy:

   J. J. Thomson
   E. E. Rutherford
   N. Bohr
   R. A. Millikan
   J. Chadwick

Materials

Matchbox
Small marble or piece of chalk
Styrofoam balls
Flannel board

18. WHAT IS INSIDE AN ATOM?

Outcomes

- Matter is electrical in nature.
- Like charges repel; unlike charges attract.

Motivation

Suspend two pith balls on strings so that they are near each other but are not touching. Rub a rubber rod with fur and hold it near each pith ball separately. Elicit the observation that the balls move apart. Ask pupils to suggest what they think caused the pith balls to repel each other.

Development

1. Elicit that both pith balls receive the same charge and that like charges repel.

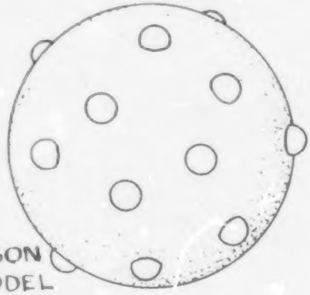
2. Rub a glass rod with silk and repeat the pith ball demonstration. Lead the pupils to conclude that both balls have similar charges and therefore repel each other.

3. Charge one pith ball with the rubber-rod and the other with the glass rod. Elicit the observation that the pith balls attract each other. Ask, "Why did the pith balls move together?" Guide the pupils to conclude that both balls received different charges and that unlike charges attract.

4. Refer to Dalton's theory and show that this theory did not explain the electrical nature of matter since Dalton described the atom as an uncharged, indivisible particle.

5. Demonstrate the Crooke's tube. Relate that J. J. Thomson experimented with this apparatus and proved that this stream of particles comes from atoms. Thomson pictured the atom as a solid ball, pockmarked with particles on the outside. He names these particles, *electrons*, and described them as very tiny units which have a negative electrical charge.

Caution: Use only tubes that are rated radiation safe.

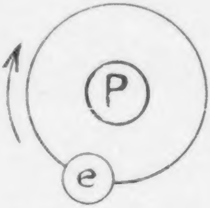


THOMSON MODEL

6. Relate Rutherford's gold leaf experiment which proved:
   a. The atom contains a positively charged particle named *proton*.
   b. The biggest part of an atom is empty space.
   c. The proton is in the center of the atom. Rutherford named this central portion the *nucleus*.

7. To emphasize the concept of space in an atom, ask the pupils to imagine an atom the size of Yankee Stadium and explain that the nucleus of this atom would be the size of a flea standing in the center of the stadium.

8. Draw a diagram to show Rutherford's concept of the atom. Explain that Rutherford compared the atom to the Solar System with the proton in the center, like the sun, and the electrons orbiting the nucleus as the planets orbit the sun.



9. Refer to the pith ball demonstration. Explain that the rubber rod took electrons from the wool, giving the rubber rod a negative charge. When the charged rubber rod touched the pith ball, the extra electrons moved from the rod to the ball, giving the pith ball a negative charge. The glass rod gave electrons to the silk, making the glass rod positive. When the positive glass rod touched the pith ball, electrons from the ball were attracted to the glass rod, making the pith ball positive. Elicit the explanation for the pith ball demonstration in terms of negative and positive charges.

Summary

1. When both pith balls were touched by the rubber rod, they (moved apart, came together).
2. When both pith balls were touched by the glass rod, they (moved apart, came together).
3. When one ball was touched by the rubber rod and the other by the glass rod, the balls (repelled each other, attracted each other).
4. Dalton's theory did not explain the ---------- nature of matter.
5. J. J. Thomson discovered the --------------------.
6. Electrons have a (negative, positive) charge.
7. Rutherford discovered the ----------------.
8. Protons have a (negative, positive) charge.

9. The biggest part of an atom is ------------------.

10. The center of the atom is called the ---------------.

11. The proton is in the -------------- of the atom.

12. The electron is found (inside the nucleus, outside the nucleus) of the atom.

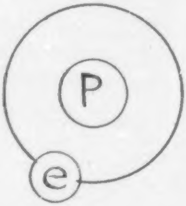
13. The rubber rod gave the pith balls a (negative, positive) charge.

14. The glass rod gave the pith balls a (negative, positive) charge.

15. Like charges ------------ and unlike charges ------------.

Homework

1. Using Rutherford's concept of the atom, draw a diagram for each of the listed atoms. Use "p" for proton and "e" for electron; i.e., hydrogen has one proton, one electron.
   a. Helium (2p, 2e)
   b. Lithium (2p, 3e)
   c. Beryllium (4p, 4e)
   d. Boron (5p, 5e)
   e. Carbon (6p, 6e)



2. *Draw the atom as Millikan, Chadwick, and Bohr envisioned it.*

Materials

Pith balls
String
Fur or wool
Silk
Ring stand and rod
Crooke's tube

19. WHAT IS THE PRESENT CONCEPT OF THE ATOM?

Outcomes

- The nucleus contains a neutral particle called a neutron.
- The electrons travel in individual orbits, in various directions, around the nucleus.

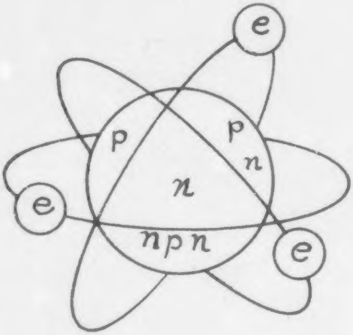
- Atoms are electrically neutral.
- *Numerous additional particles, such as the meson, positron, and neutrino, have been discovered in the nucleus.*

Motivation

Use a demonstration magnetic atom model to construct a simple Rutherford atom. Recall that the positively charged proton is in the nucleus; the negatively charged electron is outside the nucleus, and the atom is largely empty space. Explain that this is not our present-day picture of the atom. Additional discoveries have been made since Rutherford's.

Development

1. *Permit the pupils to present the reports assigned in the previous lesson.*
2. Relate to the class that in 1932, James Chadwick, who was an assistant to Rutherford, proved that there is another particle in the nucleus. He showed that this particle is the same size as a proton but has no charge. This particle was named *neutron.*
3. Explain that the Rutherford atom was further modified by the discovery of a Danish scientist, Niels Bohr. He found that some electrons in an atom have more energy than other electrons. He proved that some electrons, therefore, must be closer to the nucleus than others and that each electron travels in its own path around the nucleus.
4. Use the atom model to show Bohr's picture of the lithium atom: 3p, 4n, 3e. Draw the diagram on the board:



5. Refer to the homework assignment of the previous lesson. Guide the pupils to realize that the number of protons in each atom equals the number of electrons. Elicit the concept that the number of positive charges equals the number of negative charges in a normal atom. Explain that the positive and negative charges balance each other, making the total charge on the atom equal zero. Establish that all normal atoms are *electrically neutral.*

6. *Demonstrate a cloud chamber. Explain that scientists, studying the tracks of particles in a cloud chamber, discovered the existence of many additional particles. For example:*

   a. *Meson (mass between a proton and an electron)—some have positive charges; some negative*

   b. *Positron (same mass as an electron)—positive charge*

   c. *Neutrino (smaller than a neutron)—emitted from the nucleus; no charge.*

7. *Allow the pupils to practice constructing atoms on the atom model; i.e.,*

Boron: 5p, 6n, 5e	*Nitrogen: 7p, 7n, 7e*
Carbon: 6p, 6n, 6e	*Oxygen: 8p, 8n, 8e*
Beryllium: 4p, 5n, 4e	

Summary

1. Rutherford thought atoms contained ---------- and ----------.

2. The biggest part of an atom is ------------.

3. The neutron was discovered by ---------------.

4. The neutron is the same size as a (proton, electron).

5. The charge on a neutron is ---------------.

6. Bohr proved that each electron travels in its own ------------- around the nucleus.

7. Normal atoms are electrically ------------ ---.

8. *Some additional particles which have been discovered in the nucleus are* -------------, -------------, *and* -------------.

Homework

1. Complete the table:

ATOM	POSITIVE CHARGES	NEGATIVE CHARGES
Hydrogen (1p, 1e)		
Carbon (6p, 6n, 6e)		
Chlorine (17p, 18n, 17e)		
Sodium (11p, 12n, 11e)		
Uranium (92p, 146n, 92e)		

2. *Report on some additional particles found in atoms.*

Materials

Demonstration magnetic atom model *Cloud chamber*

20. WHAT GIVES THE ATOM ITS WEIGHT?

Outcomes

- *Atomic number* means the number of protons in an atom.
- *Atomic weight* equals the number of protons plus the number of neutrons.
- The number of neutrons in an atom can be calculated by subtracting the atomic number from the atomic weight.

Motivation

Weigh a large piece of fruit (apple or orange) on a triple-beam balance. Write the weight (to the nearest tenth of a gram) on the board. Add 3 or 4 bits of paper to the pan. Ask, "Do the bits of paper make a difference in the weight? Why?"

Development

1. Elicit that the addition of the tiny pieces of paper made no noticeable difference in the weight because the weight of the paper is very small compared to that of the sample.

2. Ask, "What part of the atom can be compared to the bits of paper?" Establish that, by comparison, the weight of an electron is also very small.

3. Ask, "What part of the atom can be compared to the fruit?" Establish that the weight of an atom is concentrated in the nucleus. Review the contents of the nucleus (protons and neutrons).

4. Explain that since atomic nuclei are so very small (an average nucleus is one five-millionth of a millionth of an inch in diameter: 1/5,000,000,000,000), we use a special weight unit. One proton or one neutron weighs one atomic weight unit. Guide the pupils to define the term *atomic weight* as the number of protons plus the number of neutrons in the nucleus.

5. Recall, from the previous lesson, that the number of protons equals the number of electrons in a normal atom. Tell the pupils that the term *atomic number* means the number of protons in an atom. Ask, "If we know the atomic number of an atom, what two facts can we state?"

6. Display a container in which 6 red balls and 5 white balls have been placed. Tell the class there are eleven balls in the container, 6 of which are red. Ask, "How many white balls are there in this container?" Elicit the answer, 5 white balls, and explain that, similarly, we can determine the number of neutrons in an atom. Refer to the container and ask, "Which number can be compared to the atomic weight? Which number can be compared to the atomic number? Which number would give us the number of neutrons?" Elicit that the atomic weight minus the atomic number equals the number of neutrons.

   At. Wgt. — At. No. = No. of neutrons

7. Drill the class in determining the numbers of protons, electrons, and neutrons as follows:

ELEMENT	SYMBOL	AT. WGT.	AT. NO.	PROTONS	ELECTRONS	NEUTRONS
Hydrogen		1	1			
Helium		4	2			
Lithium		7	3			
Beryllium		9	4			

Summary

1. The weight of an atom is concentrated in the -------- of the atom.
2. The nucleus of an atom contains ---------- and ----------.
3. It would take almost 2,000 ---------- to make the size of one proton or one neutron.
4. Atomic weight equals the number of -------- plus the number of --------.
5. The number of protons in a normal atom equals the number of ------------.
6. The atomic number means the number of ------------.
7. Atomic weight minus atomic number equals the number of ------.

Homework

Complete the following table:

ELEMENT	SYMBOL	AT. WGT.	AT. NO.	PROTONS	ELECTRONS	NEUTRONS
Boron		11	5			
Carbon				6		6
Nitrogen			7			7
Oxygen		16			8	
Chlorine		35	17			

Materials

Fruit (apple or orange)
Triple-beam balance
Bits of paper
Container
6 red balls
5 white balls

21. WHAT INFORMATION DOES THE PERIODIC TABLE GIVE US?

Outcomes

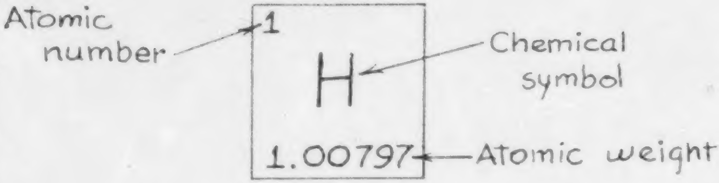
- The Periodic Table is an arrangement of the 90 natural and 15 man made elements known to man.
- The elements are arranged in order of ascending atomic number.
- The atomic weight of each element is listed in each box.
- *The atomic weight is an average of the weights of the isotopes.*

Motivation

Display a large Periodic Table and relate the story of Mendelee In 1869, Mendeleev listed the elements, known at that time, in th order of their atomic weights. He arranged the elements in the for of a table of eight columns and found that elements with simil properties fitted into the same columns, or groups, in the table. H table showed that as the elements increased in atomic weight, the was a regular and gradual change in the properties of the elemen within each group. There were several elements that seemed to b missing and other elements that did not seem to be in the right plac For example, Argon (atomic weight 40) had to be put ahead potassium (atomic weight 39) to keep each element in its corre group. Mendeleev predicted that additional elements would be di covered. The discovery by Henry Mosely of atomic numbers made possible to rearrange the elements in the table according to the atomic numbers instead of their atomic weights.

Development

1. Draw a diagram on the board, as follows, and label all parts:



2. Point out the arrangement of the elements in order of ascending atomic number.

3. Elicit that there are 105 elements known at present. Explain that all but two (#43 and 61) of the first 92 elements were discovered on earth and that the last thirteen elements (#93 to 105) were made by man. Identify elements 1-92 as the natural elements and elements 93-105 as *man-made* or transuranium elements.

4. Draw attention to the figures for the atomic weights. Explain that, for ease of computation, these figures are rounded off to the nearest whole number. Practice rounding off atomic weights with the class.

   For example: (See Periodic Table)

ELEMENT	ATOMIC WEIGHT →	ROUNDED OFF
He	4.0026	4
Li	6.939	7
B	10.811	11
C	12.011	12
Cl	35.453	35
Cu	63.54	64

5. *Explain briefly that there are usually several forms of the same element found in nature. The forms differ in the number of neutrons in the nucleus. Identify these different forms of an element as* ISOTOPES. *Tell the class that varying the number of neutrons does not alter the properties of the atom. (This will be explained in a future lesson.) Elicit that varying the number of neutrons changes the weight of an atom. Establish that the reason for the decimal in the atomic weight figures is the fact that this is an average of the weights of the isotopes.*

Summary

1. The Periodic Table was developed by ____________________.
2. Elements are arranged in order of their ____________________.
3. There are ____________ natural elements.
4. Man has made ____________ elements.
5. The total number of elements known today is ___________.
6. Atomic weights are rounded off to the nearest ________ ________

Homework

1. Complete the following chart:

ELEMENT	ATOMIC WEIGHT	ATOMIC NO.	PROTONS	ELECTRONS	NEUTRONS
Li	6.939	3			
N	14.0067	7			
Ar	39.948	18			
Zn	65.37	30			
Cu	63.54	29			

2. Distribute individual Periodic Tables to each pupil. Instruct them to complete the following chart:

ELEMENT	ATOMIC WEIGHT	ATOMIC NO.	PROTONS	ELECTRONS	NEUTRONS
S					
Ne					
K					
Co					
I					
U					
Ca					

Materials

Large Periodic Table

Individual Periodic Tables

22. HOW ARE THE ELECTRONS ARRANGED AROUND THE NUCLEUS IN AN ATOM?

Outcomes

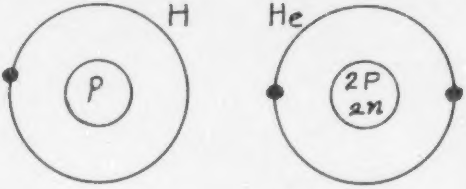
- Electrons are arranged in shells, designated by the letters *K*, *L*, *M*, etc.
- Each shell contains a specific number of electrons.

Motivation

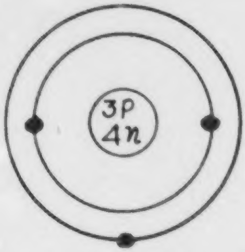
Refer to the atomic diagrams drawn by the pupils in previous lessons. Recall that like charges repel. Ask, "Why is it *not* possible for all of the electrons to travel in the same path around the nucleus?" Establish that electrons repel each other and tend to move as far apart as they can. Explain that there is a definite arrangement of electrons around the nucleus and that this pattern is the same for all atoms.

Development

1. The paths in which the electrons travel around the nucleus are called *shells*. Tell the pupils that scientists arbitrarily labelled these shells *K*, *L*, *M*, etc.
2. Use the magnetic atom model to make a hydrogen atom and a helium atom. Explain that the K shell, which is closest to the nucleus, can hold a maximum of two electrons. Draw diagrams of the hydrogen and helium atoms on the chalkboard, using dots to designate electrons.



3. Refer to the lithium atom and ask, "What happens to the third electron?" Make a model of the lithium atom and draw a diagram on the chalkboard. Elicit that the third electron is in the L shell.



4. Explain that the *L shell* can hold a maximum of eight electrons. Elicit that, therefore, sodium has two electrons in the *K shell*, eight in the *L shell*, and one electron in the *M shell*. Ask a pupil to draw a diagram of the sodium atom on the chalkboard. State that the outer shell does not hold more than eight electrons.
5. Ask a volunteer to draw a diagram of potassium (19 p, 20 n, 19 e) and establish the structure: K = 2, L = 8, M = 8, N = 1.
6. Display a large Periodic Table. Permit pupils to practice drawing electron configurations for various atoms.
7. *Recall that electrons further from the nucleus have more energy than those closer to the nucleus. Therefore, each shell represents a different energy level.*

Summary

1. The paths in which electrons travel around the nucleus are called ________________.
2. The maximum number of electrons the K shell can hold is ______.
3. The maximum number of electrons the L shell can hold is ______.
4. The outermost shell cannot hold more than ________ electrons.
5. *The formula for finding the maximum number of electrons in a shell is ____________.*

Homework

1. Draw electron diagrams for the following atoms:
2. *Draw electron diagrams for the following atoms:*

Element	Atomic Weight	Atomic No.
Be	9	4
C	12	6
Al	27	13
Ar	40	18
Ca	40	20

Element	Atomic Weight	Atomic No.
Br	80	35
Kr	84	36
Zn	65	30

Materials

Periodic Table

Magnetic atom model

23. HOW DO ATOMS COMBINE TO FORM MOLECULES?

Outcomes

- Most atoms are complete when their outermost shells contain eight electrons.
- Compounds are formed when metals lend electrons, and nonmetals borrow electrons to complete their outermost shells.

Motivation

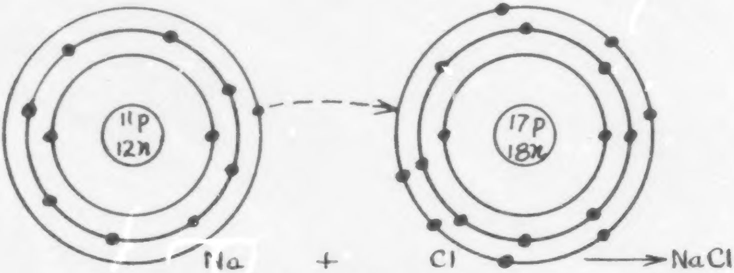
Recall that the maximum number of electrons in the outermost shell of any atom is eight. Explain that all atoms are complete when their outermost shells have eight electrons. Display a large Periodic Table. Draw a diagram of the sodium atom on the chalkboard. Ask, "How can sodium complete its outermost shell?"

Development

1. Guide the pupils to realize that it is easier for sodium to lend one electron than to borrow seven electrons.
2. Refer to the Periodic Table and ask, "Which atom will be complete by the addition of one electron to its outermost shell?"

3. Lead the pupils to understand that chlorine will borrow one electron, rather than lend seven electrons, to complete its outermost shell.

4. Draw a diagram on the chalkboard to show how sodium and chlorine combine to form a molecule of the compound, sodium chloride.



5. Refer to the Periodic Table and ask, "What other element will combine with an atom of chlorine?" Guide the pupils to realize that every element in Group I has one electron in its outermost shell. Lead to the conclusion that each element in Group I can lend one electron.

6. Call upon pupils to draw diagrams of magnesium and beryllium on the chalkboard. Have the class locate these elements on the Periodic Table. Elicit that elements in Group II can lend two electrons.

7. Repeat this procedure for Groups III, V, VI and VII. Elicit the conclusions that:
   a. elements in Group III can lend three electrons
   b. elements in Group V can borrow three electrons
   c. elements in Group VI can borrow two electrons
   d. elements in Group VII can borrow one electron

8. Permit volunteers to draw diagrams of helium and neon. Elicit that the outermost shells of these atoms are complete. Ask, "Will elements in Group O combine to form compounds?" Establish that, under normal circumstances, these elements will not combine and are therefore called *inert*.

9. Call attention to Group IV and establish that these elements can either lend four electrons or borrow four electrons.
10. Recall that elements in Groups I, II, and III are metals. Elicit the conclusion that metals are electron-lenders.
11. Recall that elements in Groups V, VI, and VII are nonmetals. Elicit the conclusion that nonmetals are electron-borrowers.
12. Guide the pupils to understand that Group IV elements can act as lenders or borrowers of electrons.

Summary

1. The maximum number of electrons in the outermost shell of an atom is ______.
2. All atoms try to complete their outermost shells with ________ electrons.
3. Elements in Group I will (lend, borrow) ______ electrons.
4. Elements in Group II will (lend, borrow) ______ electrons.
5. Elements in Group III will (lend, borrow) ______ electrons.
6. Elements in Group IV will ________ or ________ 4 electrons.
7. Elements in Group V will (lend, borrow) ______ electrons.
8. Elements in Group ______ will borrow two electrons.
9. Elements in Group VII will (lend, borrow) one ______________.
10. Elements in Group O are called ________________.
11. The outermost shells of Group O elements are (complete, incomplete).
12. Metallic elements are electron (borrowers, lenders) and are in Groups ______, ______, and ______.
13. Nonmetallic elements are electron (borrowers, lenders) and are in Groups ______, ______, and ______.

Homework

1. From the list, select elements which will combine to form compounds. Make five different combinations and draw diagrams of

the atoms to show how they will combine. (Refer to the sodium chloride diagrams in the lesson.)

a. Sodium (Na): 11 p, 12 n, 11 e
b. Magnesium (Mg): 12 p, 12 n, 12 e
c. Potassium (K): 19 p, 20 n, 19 e
d. Oxygen (O): 8 p, 8 n, 8 e
e. Chlorine (Cl): 17 p, 18 n, 17 e
f. Sulfur (S): 16 p, 16 n, 16 e

2. Name each of the 5 compounds you made.

Materials

Periodic Table	Magnetic atom model

24. HOW ARE COMPOUNDS FORMED?

LABORATORY LESSON

Outcomes

- Electron-lenders will combine with electron-borrowers to form compounds.
- The chemical formula of a compound represents the number and kinds of atoms that combine to form a molecule of the compound.

Motivation

Display and identify the solutions to be used in the lesson. Tell the pupils they are going to combine solutions to form new compounds.

Development

1. Distribute the materials.
2. Caution the pupils to be sure reagent bottles are capped after each use. Warn them to be careful not to get the solutions on their hands. Silver nitrate will leave brown stains on the skin.

Homework

Complete the following equations and explain why the compounds will form:

$Mg + O_2 \rightarrow$ ____

$H_2 + O_2 \rightarrow$ ____

$Fe + S \rightarrow$ ____

$Hg + O_2 \rightarrow$ ____

$H_2 + Cl \rightarrow$ ____

Materials

Prepare 10% solution of each: $NaCl$, $AgNO_3$, $Pb(NO_3)_2$, KI.

NOTE: To prepare a 10% solution, weigh out 10 grams of the compound and add enough water to make 100cc of solution.

Test tube racks
Test tubes
Medicine dropper
Copper turnings
Dilute hydrochloric acid

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 24

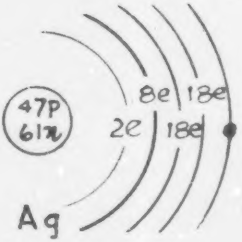
Problem: How can we form new compounds?

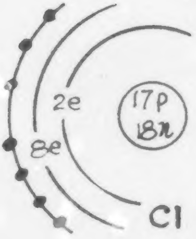
Materials

Test tube racks
3 test tubes
Medicine droppers
Sodium chloride ($NaCl$)
Silver nitrate ($AgNO_3$)
Copper turnings (Cu)
Dilute hydrochloric acid (HCl)
Lead nitrate [$Pb(NO_3)_2$]
Potassium iodide (KI)

Procedures and Observations

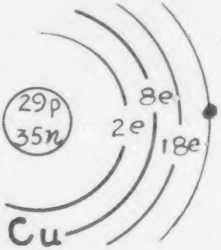
1. Place 10 drops of $NaCl$ into a test tube and add 5 drops of $AgNO_3$.
   a. The color of the solid which forms is ________________.
   b. Complete the equation for this reaction:
      $NaCl + AgNO_3 \rightarrow NaNO_3 +$ ________________
   c. Draw an arrow on this diagram to show how this compound was formed.
      (SEE NEXT PAGE FOR DIAGRAM.)
   d. ______________ is the electron-lender and ______________ is the electron-borrower.

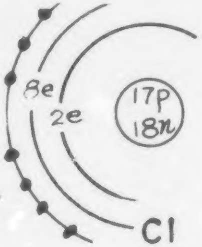




2. Place some copper turnings into a test tube and add 10 drops of dilute HCl.
   a. The color of the solution is ________________.
   b. Complete the equation for this reaction:

      $2Cu + 2HCl \rightarrow 2$ __________ $+ H_2$
   c. Draw an arrow on the diagram to show how the compound was formed.





   d. ______________ is the electron-lender and ______________ is the electron-borrower.

3. *Place 10 drops of* $Pb(NO_3)_2$ *in a test tube and add 10 drops of KI.*
   a. *The color of the solid is* ________________.
   b. *Complete the equation for this reaction:*

      $Pb(NO_3)_2 + 2KI \rightarrow 2KNO_3 +$ ________________
   c. Since this atom of lead has two electrons in its outside shell and iodine has seven electrons in its outside shell, how many atoms of iodine will combine with one atom of lead? ________________________
   d. The electron-lender is __________ and the electron-borrower is __________

Conclusions

1. Electron-lenders are (metals, nonmetals).
2. Electron-borrowers are (metals, nonmetals).
3. Metals combine with nonmetals to form ________________.

4. Complete the following chart:

COMPOUND	ELEMENT	NO. OF ATOMS	ELEMENT	NO. OF ATOMS
	Ag	1	Cl	1
CuCl				
PbI_2				

5. The chemical formula of a compound tells the ____________ and ____________ of atoms that combine to form the compound.

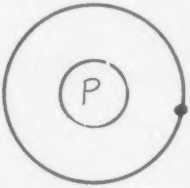
25. WHAT HAPPENS TO THE ELECTRONS WHEN COMPOUNDS ARE FORMED?

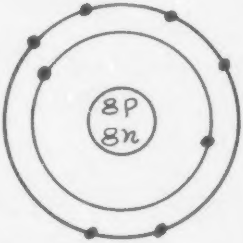
Outcomes

- Electrons can move from one atom to another to form compounds.
- Atoms of one element may share electrons with atoms of another element to form compounds.

Motivation

Draw diagrams of hydrogen and oxygen on the chalkboard as follows:





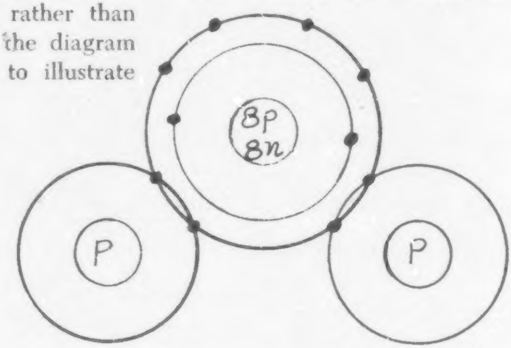
Ask, "How many atoms of hydrogen are needed to complete the outside shell of the oxygen atom?" Establish that two atoms of hydrogen are necessary. Elicit that the compound thus formed is water (H_2O).

Development

1. Ask, "What would happen to the hydrogen atom if it gave up its electron to the oxygen atom?" Establish that it would no longer be an *atom* of hydrogen.

2. Ask, "How many electrons does hydrogen need to complete its outer shell?" Elicit that the outer shell of hydrogen is complete with two electrons.

3. Explain that to complete the outer shells of all of the atoms involved, electrons are *shared* between the hydrogen atoms and the oxygen atom, rather than transferred. Draw the diagram of the compound to illustrate this.



Summary

1. When a compound is formed, ________________ move from one atom to another atom.

2. One atom of oxygen needs ______________ atoms of hydrogen to complete its outer shell.

3. The outer shell of hydrogen is complete with __________ electrons.

4. Oxygen __________________ electrons with hydrogen to form the compound, H_2O.

5. Atoms of one element may ________________ electrons with atoms of another element to form a __________________.

Homework

A molecule of oxygen consists of two atoms of oxygen (O_2).
Draw a diagram to show the sharing of electrons between the two oxygen atoms. (Oxygen: 8p, 8n, 8e.)

REVIEW AND REINFORCEMENT (17—25)

Completion

A. FILL IN THE BLANKS

1. Molecules are made of particles called ____________.
2. The basic unit of all matter is the ____________.
3. The first one to use the word, "atom", was ________________.
4. Dalton said that atoms are solid, ________________ particles.
5. When a rubber rod is rubbed with fur, the rod becomes ________ charged.
6. When a glass rod is rubbed with silk, the rod becomes _________ charged.
7. Like charges ____________, unlike charges ____________.
8. Rutherford proved that the atom is made up mainly of _________.
9. Atoms are made up of smaller particles called ________, ________, and ________.
10. Thomson discovered the ____________.
11. Rutherford discovered the ____________.
12. The center portion of the atom is called the ____________.
13. Chadwick discovered the ________________.
14. The particles which are the same size are ________ and ________.
15. An electron is ________ times smaller than a proton.
16. An electron has a ____________ charge.
17. A proton has a ____________ charge.
18. A neutron has ____________ charge.
19. Atomic weight equals the number of ________ plus the number of ________.
20. Atomic number means the number of ____________.
21. Normal atoms are electrically ____________.

22. The number of protons equals the number of __________ in an atom.

23. The atomic weight minus the atomic number equals the number of ________________.

24. Elements are listed according to __________ __________ on the Periodic Table.

25. There are _________ natural elements and _________ man-made elements known today.

26. The nucleus contains __________ and __________.

27. Electrons are found __________ the nucleus.

28. The paths in which the electrons travel are called ____________.

29 Elements in Group IV have ________ electrons in the outermost shell.

30. Metals are electron ____________, and nonmetals are electron ____________.

B. COMPLETE THE FOLLOWING CHART:

ELEMENT	SYMBOL	ATOMIC WEIGHT	ATOMIC NO.	PROTONS	NEUTRONS	ELECTRONS
Potassium		39	19			
Lead		207	82			
Aluminum				13	14	
Nitrogen		14			7	
Neon			10		10	
Chlorine		35				17

Diagrams

Draw electron diagrams for these atoms:

Lithium (At. Wgt. 7, At. No. 3)

Boron (At. Wgt. 11, At. No. 5)

Oxygen (At. Wgt. 16, At. No. 8)

Helium (At. Wgt. 4, At. No. 2)

Beryllium (At. Wgt. 9, At. No. 4)

Choice and Essay

Which of these combinations will form compounds? Explain your answer.

1. Lithium + boron
2. Helium + beryllium
3. 2 lithium + oxygen
4. Beryllium + oxygen

Research Topics

1. What Is Radioactivity?
2. The Nuclear Reactor
3. How Atomic Energy Is Used to Make Electricity
4. How Atomic Energy Is Used in Medicine
5. How Atomic Energy Is Used in Agriculture

Trips

1. Hall of Science, American Museum of Natural History
2. Hall of Science, Flushing Meadow Corona Park, Flushing
3. Con Edison Atomic Energy plant at Indian Point

Films and Filmstrips (BAVI)

Strange Case of the Cosmic Rays

Our Friend, the Atom

SUGGESTED UNIT EXAMINATION: CHEMISTRY

Multiple Choice

1. The building blocks of matter are called
a) compounds b) solids c) elements d) mixtures

2. Matter is anything:
a) that can be seen b) that has weight and takes up space
c) that has luster d) that has color

3. An example of a nonmetal is
a) sulfur b) magnesium c) sodium d) iron

4. The modern Periodic Table shows
a) an alphabetical listing of the elements
b) elements arranged in order of increasing atomic number
c) elements arranged in order of increasing atomic weight
d) a list of elements and compounds

5. The similarities and differences in matter are called
a) states b) metals c) nonmetals d) properties

6. The setup used to separate water into its elements is called
a) water trough b) magnetic model c) Hoffman apparatus
d) electric circuit

7. A gas which causes a glowing splint to burst into flames is
a) hydrogen b) oxygen c) chlorine d) carbon dioxide

8. A gas which explodes when a burning splint is thrust into it is
a) hydrogen b) oxygen c) chlorine d) carbon dioxide

9. Oxygen may be prepared from
a) heat b) electricity c) water d) iron

10. An element which has luster and color is
a) a nonmetal b) a gas c) a metal d) a solid

11. The symbol for neptunium is a) N b) Ne c) Nt d) Np

12. Elements combine to form
a) gases b) mixtures c) liquids d) compounds

13. The properties of compounds are
a) the same as those of the elements
b) different from those of the elements
c) the same as the properties of mixtures
d) the properties of the combining metal

14. The elements in the compound, NaOH are
a) sodium, oxygen and hydrogen
b) nitrogen, argon, hydrogen and oxygen
c) neon, oxygen and helium
d) nickel, oxygen and mercury

15. $ZnCl_2$ is the formula for
a) zinc carbonate b) iron chloride c) zinc chloride
d) zinc oxide

16. The symbol equation for the formation of water is
a) $H + O \rightarrow HO$ b) $2H_2 + O_2 \rightarrow 2H_2O$
c) $H + W \rightarrow HW$ d) $W + A \rightarrow WA$

17. The symbol equation for the breaking down of water is
a) $HO \rightarrow H+O$ b) $2H_2+O_2 \rightarrow 2H_2O$
c) $WA \rightarrow W+A$ d) $2H_2O \rightarrow 2H_2+O_2$

18. In the equation $Zn+2HCl \rightarrow ZnCl_2+$ ----, the missing term is
a) Zn b) Cl_2 c) H_2 d) O_2

19. When steel wool is burned in air
a) it evaporates b) its weight increases
c) its weight decreases d) there is no change in its weight

20. When steel wool is burned in air
a) it combines with oxygen b) carbon dioxide is given off
c) water vapor is given off d) it explodes

21. The main element in steel wool is
a) oxygen b) iron c) chlorine d) steel

22. The smallest part of a substance which still has the properties of that substance is called a
a) mixture b) compound c) atom d) molecule

23. Carbon dioxide is
a) heavier than air b) lighter than air
c) twice as heavy as air d) the same weight as air

24. Carbon dioxide forms a milky solution when mixed with
a) iodine b) hydrochloric acid c) lime water
d) silver nitrate

25. When magnesium burns in air
a) heat energy is given off
b) heat and light energy are given off
c) no energy change occurs
d) magnesium sulfide is formed

26. The reaction in which heat energy is absorbed is
a) burning magnesium
b) burning paper
c) changing mercuric oxide into mercury and oxygen
d) burning steel wool

27. When iron filings are mixed with sulfur
a) a physical change occurs b) a chemical change occurs
c) a compound is formed d) energy is given off

28. When a mixture of iron and sulfur is heated
a) a physical change occurs b) a chemical change occurs
c) a mixture is formed d) iron oxide is formed

29. Sugar dissolved in water is an example of
a) a mixture b) a compound c) an element d) a molecule

30. The elements are *not* in a definite fixed ratio in
a) iron oxide b) iron sulfide c) magnesium oxide
d) sugar solution

31. A formula may be written for
a) an element b) a mixture c) a compound d) a metal

32. To remove sand from a mixture of sand and water, use the process
a) solution b) filtration c) magnetism
d) chemical reaction

33. The name of a compound, written in symbols, is called
a) an equation b) an element c) a formula
d) a reaction

34. The symbol equation for the burning of steel wool in air is
a) $Fe + H_2 \rightarrow FeH_2$ b) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$
c) $I + O_2 \rightarrow IO_2$ d) $S + O \rightarrow SO$

35. The formula for carbon dioxide is
a) C_2O b) CO c) CH_2 d) CO_2

36. The part of Dalton's theory which has been proven false is
a) all matter is made of atoms
b) the atoms of one element are alike
c) atoms cannot be broken down into anything simple
d) compounds are made of atoms

37. The electron was discovered by
a) Thomson b) Dalton c) Rutherford d) Chadwick

38. The biggest thing in an atom is
a) electron b) proton c) neutron d) space

39. The proton was discovered by
a) Thomson b) Dalton c) Rutherford d) Chadwick

40. The present-day picture of the atom was suggested by
a) Rutherford b) Bohr c) Dalton d) Einstein

41. The total number of elements known today is
a) 102 b) 100 c) 92 d) 103

42. The atomic number equals the number of
a) protons b) neutrons c) electrons
d) protons plus neutrons

43. The nucleus of an atom contains
a) electrons b) protons and neutrons c) only protons
d) protons and electrons

44. The maximum number of electrons in the K-shell is
a) 8 b) 18 c) 2 d) 12

45. The maximum number of electrons in the outermost shell of an atom is
a) 8 b) 18 c) 2 d) 12

46. Elements in Group O are called
a) active b) electron-lenders c) inert
d) electron-borrowers

47. Metallic elements are
a) gases b) electron-lenders c) inert
d) electron-borrowers

48. The lightest element is
a) oxygen b) helium c) nitrogen d) hydrogen

49. A magnet may be used to separate
a) a compound of iron and sulfur
b) a mixture of iron and sand
c) a compound of iron and oxygen
d) a mixture of sulfur and sand

50. Water is
a) a compound b) a mixture c) an element d) an acid

Completion

1. Anything that has weight and takes up space is called _________.

2. The three forms of matter are ________, ________, and ________.

3. When a solid is heated, it changes into a ____________.

4. When a liquid is heated, it changes into a ____________.

5. When a gas is cooled, it changes into a ____________.

6. The state of matter of a substance may be changed by adding or subtracting ____________ energy.

7. In the Hoffman apparatus, ____________ energy is used to break up water.

8. The building blocks of matter are called ____________.

9. Descriptions or characteristics of a substance are called ________.

10. Three properties of metals are ________, ________, and ________.

11. The only metal which is a liquid is ____________.

12. Elements can be divided into two groups: _______ and _______.

13. Nonmetals do not conduct ____________.

14. Elements are arranged in a special order on the _________ Table.

15. An element which supports burning is ____________.

16. A substance which takes the shape of the entire container is in the ____________ state.

17. A substance which has a definite shape is in the __________ state.

18. Elements combine to form ____________.

19. The name of a compound, written in symbols, is called its ____________.

20. Compounds can be broken down into their ____________.

21. Oxidation is the combining of a substance with ____________.

22. The formula H_2O represents one ____________ of water.

23. A compound consists of a _________ combined with a _________.

24. A physical change is a change in ________, ________, or ________.

25. A chemical change results in the formation of a ____________.

26. The first person to use the word "atom" was ____________.

27. The basic unit of all matter is the ____________.

28. The center of the atom is called the ____________.

29. Electrons have a __________ electrical charge.

30. Like charges __________ and unlike charges __________.

31. The charge on a neutron is ____________.

32. Normal atoms are electrically ____________.

33. It would take almost 2000 __________ to equal the weight of one proton.

34. Atomic weight minus atomic number equals the number of ____________.

35. The paths in which electrons travel around the nucleus are called ____________.

Essays

Give a brief explanation of each of these statements.

1. Although water consists of hydrogen which explodes and oxygen which supports burning, water may be used to put out fires.
2. A rubber rod will not be attracted to paper unless it is first rubbed with wool.
3. Oxygen (atomic weight 16, atomic number 8) is not likely to combine with chlorine (atomic weight 35, atomic number 17).
4. In the separation of sand, salt, and water, filtration is used before evaporation.
5. Mendeleev was able to predict the existence of elements although they had not been discovered yet.
6. Scientists predicted the existence of particles inside the atom before they could demonstrate their existence.

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Unit II

PHYSICS

Electricity
Magnetism
Heat

85/86

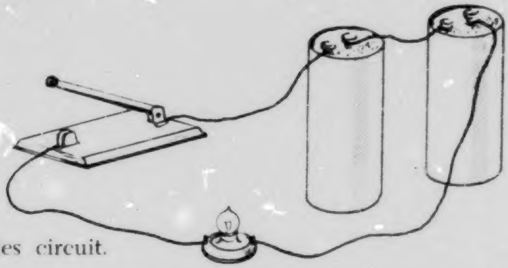
ELECTRICITY

Suggested Lessons and Procedures

1. WHAT IS MEANT BY AN ELECTRIC CURRENT?

Outcomes

- An electric current is a flow of electrons.
- In an electric circuit the electrons flow from the negative to the positive terminal.



Motivation

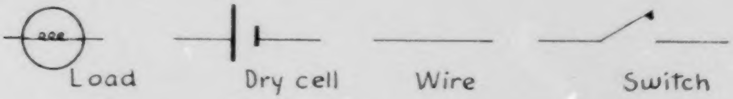
Display a simple series circuit.

Use it to review the concepts and definitions developed in the K-6 science activities:

dry cell
conducting wire
load (3V)—device in circuit which is operated by the flow of electrons; e.g., lamp, motor, bulb in socket, etc.
switch
open circuit—switch open
closed circuit—switch closed
electrons—negative units of charge.

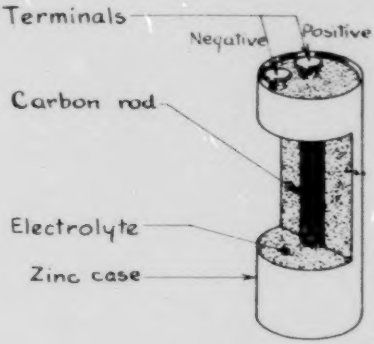
Development

Explain to the class that in the same way that chemists use symbols to represent the elements, physicists use symbols to represent various parts of electric circuits. Introduce and have the class copy into their notebooks these symbols:



1. Use the chalkboard or overhead projector to illustrate the proper method of drawing circuit diagrams. Indicate the movement of electrons from the negative to the positive terminal. Define the flow of electrons as an electric current. Emphasize that the electrons are moving from the negative to the positive terminal.

2. *Display a cutaway dry cell. Connect it in series with a lamp and ammeter to show that it will still operate in its cutaway condition. Draw a diagram of the cell on the board and identify its parts.*
   NOTE: Enlist the aid of the Industrial Arts Department to cut the dry cell.



Summary

1. Point to various parts of the electric circuit and have the class identify them.
2. The charge on the electron is ________________.
3. In an electric circuit electrons move from the __________ terminal to the __________ terminal.

Homework

1. What is an electric current?
2. Draw a diagram of the electric circuit used in today's lesson. Label all the parts.
3. *Draw a diagram of a cutaway dry cell and label all its parts.*

Materials

Assorted wires
1½V lamp in base
Switch
Cutaway dry cell

2. WHAT IS A SERIES CIRCUIT?

LABORATORY LESSON

Outcome

- A series circuit is one in which the electrons have only one path to follow.

Motivation

Display a string of lights wired in series. Connect these lights to a source of current and have the class note that all the lamps are lit. Disconnect one of the lamps and challenge the class to explain what is seen. (All lights go out.)

Development

1. Demonstrate how to connect the dry cells in series. Point out that the terminal in the middle is called the positive terminal or anode and is marked (+). The rim terminal is the negative terminal or cathode and is marked (—).

   Note: To facilitate assembly and disassembly of circuits used in Lessons 2 and 3, you may wish to mount two miniature lamp sockets and associated clips on a plywood board.

2. Distribute materials to each group of pupils.

Homework

1. Find an example of a series circuit in your home and draw a circuit diagram of it.
2. Draw a diagram of a circuit with 2 dry cells, 1 switch, and 3 lamps. What will happen to the lamps if one of them burns out?

Materials

String of lamps wired in series
Power supply

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—PHYSICS: LESSON 2

Problem: What are some properties of series circuits?

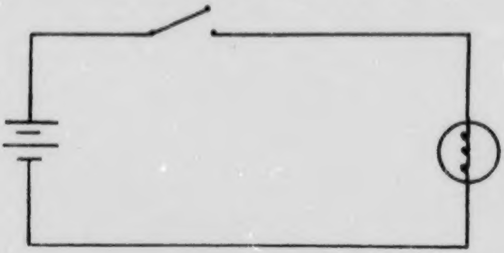
Materials

2 dry cells, No. 6 – 1½V
Small screwdriver
Switch
2 – 1½V lamps in miniature sockets
Bell wire, ends bared ½"
  3 – 12" lengths
  2 – 6" lengths

Procedures and Observations

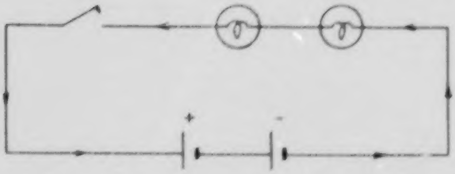
Make sure that your teacher checks and approves your circuits before you close the switch.

1. Connect the two dry cells as shown by your teacher. Use one lamp, 2 dry cells, the switch, and the wires to make the simple circuit shown:



   Close the switch and note the brightness of the lamp.

2. Open the switch and remove a wire from one side of the lamp socket. Place another socket in series with the first one as shown in the diagram:



3. Compare the brightness of the lamps, when two are in the circuit, with the brightness when only one is in the circuit.

4. *Definition:* An electric circuit that has only one path for the electrons to follow is called a *series circuit.*

5. Unscrew one of the lamps in your *series circuit* and record what happens to the other lamp.

Conclusions

1. What are the disadvantages of a series circuit with more than one load?

2. Write a lab report based on the work you did today. Be sure to include diagrams of the circuits that you have used.

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3. WHAT IS A PARALLEL CIRCUIT?

LABORATORY LESSON

Outcomes

- Parallel circuits provide more than one path for the electrons to follow.
- Parallel circuits permit independent operation of each load in the circuit.

Motivation

Display a set of light bulbs wired in parallel (do not call attention to the fact that the circuit is wired in parallel). Connect the lamps to a power source and ask what will happen if one bulb is disconnected. Tell the class that, in this lesson, they will have an opportunity to investigate this new circuit.

Development

1. Review the proper method of connecting two dry cells in series.

2. Distribute the materials.

NOTE: If time permits, the teacher may wish to omit the circuit diagrams on the Worksheet and challenge the pupil to discover a way to connect the lamps so that when one is disconnected, the other remains lit.

3. *Distribute to each group an extra miniature socket, with bulb and attached wires. Challenge the groups to design a parallel circuit with loads.*

Homework

1. Many household lighting fixtures use two or more bulbs. How are these bulbs wired (series or parallel)? Why?

2. Draw a diagram of a circuit with three loads in parallel, a dry cell, and one switch.

Materials

String of lamps wired in parallel

Power supply

Extra set of miniature sockets with bulbs and attached wires

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—PHYSICS: LESSON 3

Problem: How can we make a parallel circuit?

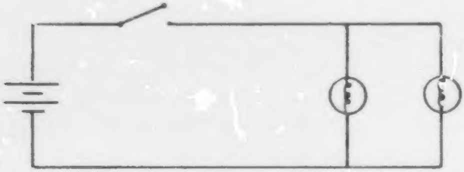
Materials

2 dry cells No. 6, 1½V
Small screwdriver
Switch
2 lamps (1½V) in miniature sockets
3 – 12" lengths and 4 – 6" lengths bell wire with ½" ends bared

Procedure and Observations

1. Connect the two dry cells in series.

2. Connect the dry cells, wires, switch, and lamps as shown on the circu diagram. Do not close the switch until the circuit is approved by the teache



3. After the circuit has been approved, close the switch and record your observations. ____

4. How does the brightness of the lamps in this circuit compare with the brightness of the two lamps in the series circuit?

5. Disconnect one of the lamps and record your observations. ________________
____

6. Define a parallel circuit.

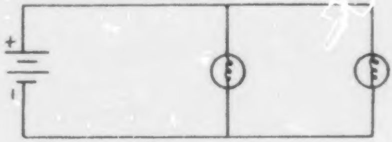
Conclusions

1. Explain the difference between a series circuit and a parallel circuit.

2. What advantages does a parallel circuit have over a series circuit?

3. Write a lab report based on the work that you did today. Be sure to include circuit diagrams of all the circuits that you have used.

4. In this diagram, indicate the path of electricity as it flows in the circuit shown.



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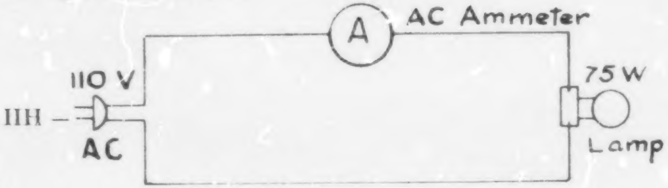
4. WHY DO SOME LIGHT BULBS BURN MORE BRIGHTLY THAN OTHERS?

Outcomes

- The thinner a wire, the greater its resistance.
- The longer a wire, the greater its resistance.

Motivation

Set up the following:



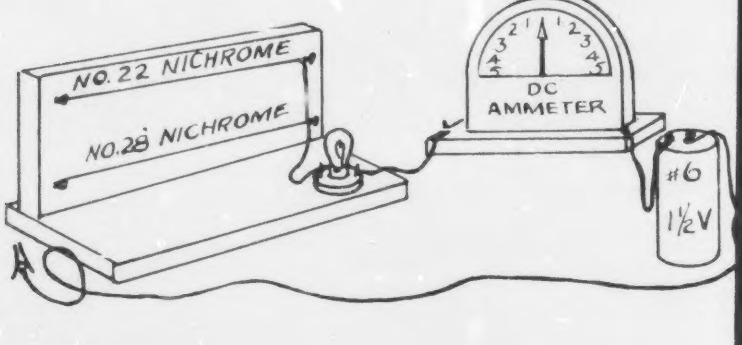
Connect the circuit to the power supply and have the class observe the deflection of the ammeter and the brightness of the lamp. Substitute a 100W lamp and then a 150W lamp. Record class observations. Challenge the class to account for these variations.

Note: Currents of about one ampere may be anticipated.

The class may determine the amount of electricity from the deflections of the ammeter needle. No attempt need be made to define the ampere in this lesson.

Development

1. By observing the deflections of the ammeter needle, establish that the brighter the light bulb, the greater the deflection of the ammeter needle.
2. Exhibit a light bulb with the glass envelope removed. Call attention to the filament and to the fact that it is a wire.
3. Set up the following (Use 1 amp. shunt on galvanometer.):



Demonstrate the effect of changing from a thick wire to a thin wire. (Attach the clip to the free end of the No. 22 wire and then to the No. 28 wire.) List the observations on the board.

WIRE THICKNESS	LAMP INTENSITY	AMMETER DEFLECTION
Thick wire	Bright lamp	Large deflection of ammeter
Thin wire	Dim lamp	Small deflection of ammeter

Develop the concept that the thin wire seems to resist the flow of electricity more than the thick wire. Define this property of a wire as its resistance.

4. Repeat the demonstration and establish the generalization that: The thinner the wire, the greater its resistance to electric current.

5. Challenge the class to think of a different way to change the resistance of the wires. Allow the pupils to try the various investigations that they suggest. If the class does not suggest a change in length, you suggest it and allow the pupils to try it. (Connect the clip to various points on the wire.)

   Develop the generalization: The longer a wire, the greater its resistance to electric current.

6. Challenge the class to suggest ways of changing the filament of a light bulb to vary its brightness. (To break the glass envelope of old 50 and 150 Watt lamps, place the lamps in a paper bag of triple thickness, and tap them lightly with a hammer. Then compare the filaments.)

Summary

1. Long wires have __________ resistance than short wires.
2. Thick wires have __________ resistance than thin wires.

Homework

1. How do the length and thickness of a wire affect its resistance?

2. Make a list of materials that have such a high resistance that they allow practically no electric current to pass through them.

Materials

AC ammeter	*Paper bags*
DC ammeter	*Hammer*
Assorted wires	
Lamp base	
50, 100, 150 W lamps	
Nichrome wire #22 and #28 (2 ft. lengths)	
Resistance board with 1½V lamp	

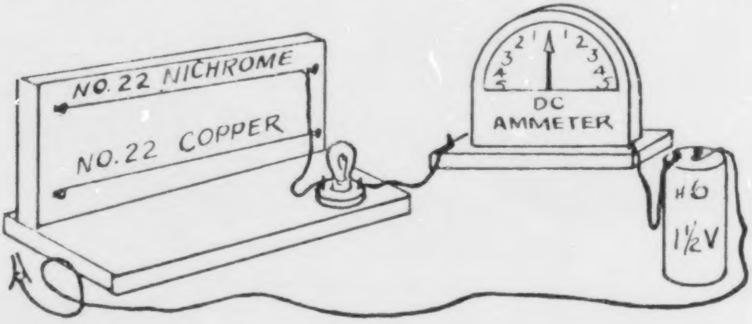
5. HOW CAN THE RESISTANCE OF A WIRE BE CHANGED?

Outcomes

- Wires of different metals differ in resistance.
- The resistance of a wire increases as its temperature increases.

Motivation

Set up the following (Use the 1 amp shunt on the galvanometer.):



Connect the clip to the terminal of the #22 copper wire and have the class record their observations of the ammeter needle and the brightness of the light bulb. Connect the clip to the terminal of the #22 nichrome wire and once again have the class record their observations.

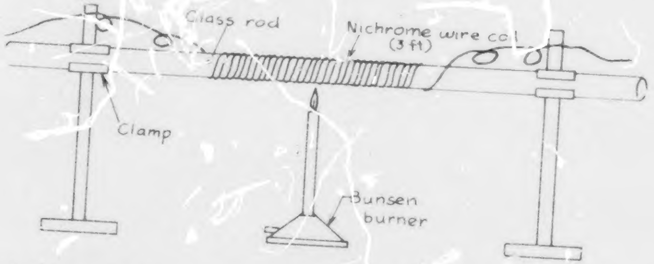
NOTE: In the demonstration used in this lesson, the teacher may anticipate small but consistent changes in the measured currents. This may be used to emphasize the importance of careful observation.

Development

1. Challenge the class to account for the observed difference in the ammeter readings and the lamp brightness. If the pupils suggest that the wires are of different thickness (they are obviously the same length), have a pupil come up and examine the wires. (Measure them with a micrometer, if one is available.)

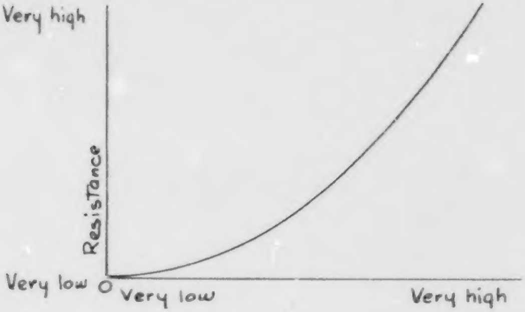
   Since the only difference between the wires is their material, different materials must have different resistance. A piece of nichrome wire has more resistance than a piece of copper wire of similar length.

2. Substitute the following for the resistance board used in the previous demonstration:



   Heat the coil of nichrome wire and have the class observe the decrease in current. Develop the generalization: The resistance of a wire increases as its temperature increases. (Show the same effect with other metal wires, e.g., iron, steel.)

3. *Challenge the class to explain what might happen to the resistance of a wire as its temperature is decreased. Use the following graph to illustrate the decrease in resistance with decrease in temperature.*



The special science that deals with low temperatures is called CRYOGENICS.

Summary

1. How is it possible for two wires of the same length and diameter to have different resistance?
2. What happens to the resistance of a wire when it is heated?

Homework

1. Which material would be better for wiring a house: nichrome wire or copper wire? Why?
2. What happens to the resistance of the filament of a light bulb after the current is turned on? Why?
3. *Make a report on one of the following topics:*

   a. Cryogenics *b. Super Conductors*

Materials

Resistance board
3 ft. coil #22 nichrome wire
6, #6 dry cells
Demonstration ammeter
Nichrome wire #22 (2 ft. length)
Copper wire #22 (2 ft. length)
Miniature lamp base with 1½V lamp
2 iron stands with clamps
Solid glass rod (2 ft. long)
Bunsen burner
Assorted wires with clips

6. HOW IS ELECTRIC CURRENT MEASURED?

Outcomes

- Electric current is measured in amperes.
- The ammeter is used to measure electric current.
- Ammeters are connected in series with the current they measure.

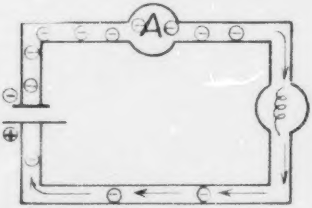
Motivation

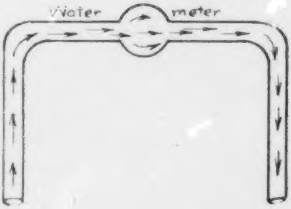
Ask the class to imagine the flow of water in a pipe. Draw, or use a transparency of, the suggested diagram. List the parts of a water pipe system on the board and have the class compare them to the parts of an electric circuit.

Water Pipes	*Electric Circuit*
Pipes	Wires
Valve	Switch
Water	Electrons
Water wheel or turbine	Load

Development

1. Challenge the class to think of some things that are measured in a system of water pipes. If the class does not suggest the amount of water flowing, the teacher may suggest it and place it at the bottom of the diagram shown. (If the class suggests pressure, add it to the chart but tell the class it is the topic for the next lesson.)
2. Display an ammeter in a simple series circuit. Draw an analogy between the water flowing in a pipe and the flow of electrons in a wire. Diagrams, such as the following, may be useful. (Use the standard symbol for an ammeter.) -Ⓐ-

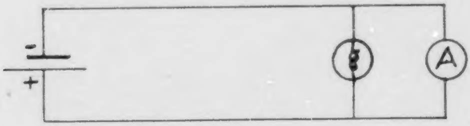


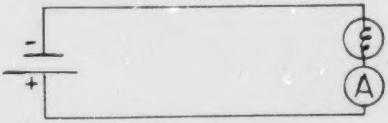


Ask the class to suggest how much water might be flowing past any point in the pipe in a second. Answers such as one gallon per second and 10 quarts per second should be encouraged. Refer to the electric circuit and point out that the flow of electrons past a given point can be measured. The unit of electric current is called the ampere.

Write these sentences on the board:
Electric currents are measured in units called amperes.
Ammeters are used to measure electric currents.

3. Display several ammeters. Point out to the class the various ranges available on these instruments. One commonly available model has three ranges: 0-3 amps, 0-15 amps, and 0-30 amps.
4. Explain the advantages of an ammeter with several ranges. Using a large demonstration ammeter, demonstrate the difficulty in measuring small currents on a scale with a large range, for example, $^{1}/_{10}$ ampere on the 0-30 range.
5. Place this diagram on the board:





Ask the class to identify the circuit in which the ammeter measures all the current coming out of the dry cell. During the discussion that follows establish that ammeters must always be placed in series with the currents that they measure.

Summary

1. An ammeter has the following ranges: 0-3, 0-15, and 0-30 amperes. Which range should you use to measure a current of ½ ampere, 2 amperes, 10 amperes?

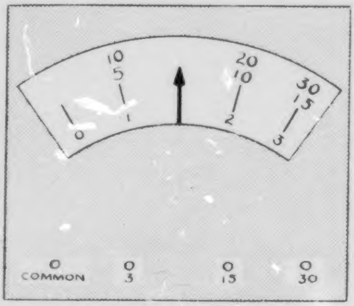
2. From memory, have the class fill in the blanks in the table:

WATER SYSTEM	ELECTRIC CIRCUITS
Pipes	
	Switch
Water	
	Load
Rate of flow (gal. per sec.)	

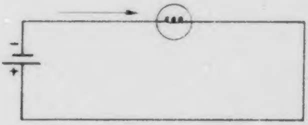
Homework

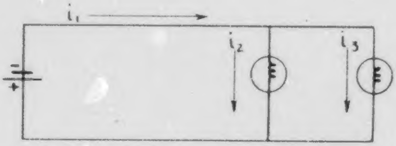
1. Using the diagram of an ammeter, answer these questions:

   How much current is flowing if the ammeter is on the
   a. 0-3 range _____________
   b. 0-15 range _____________
   c. 0-30 range _____________?


10
5
1
0
20
10
2
30
15
3
0 COMMON
0 3
0 15
0 30

2. Show in a neat diagram how to connect an ammeter to measure the current in each of these circuits:




i_1
i_2
i_3
-
+
Current i_1, i_2, i_3

Materials

Several ammeters	2, #6 dry cells
Large demonstration ammeter	Assorted wires with clips

Miniature lamp in base (small electric motor may be substituted)

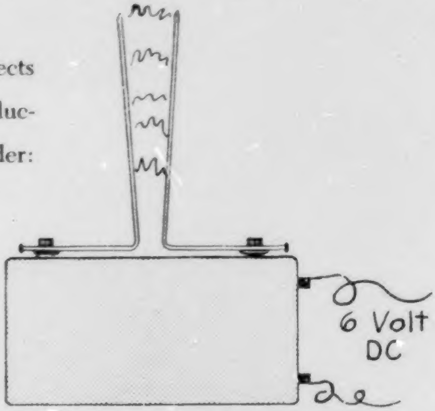
7. HOW IS ELECTROMOTIVE FORCE MEASURED?

Outcomes

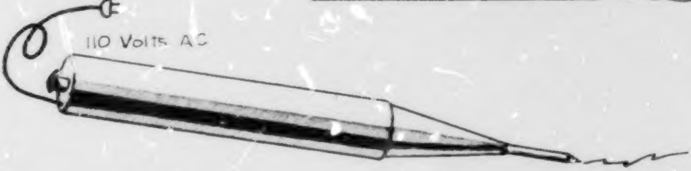
- Electromotive force is measured in volts.
- Electromotive force is measured with a voltmeter.

Motivation

Demonstrate some of the effects of high voltage. Set up an induction coil with a Jacobs Ladder:



Demonstrate the Tesla Coil.



Compare the effects produced by these instruments to those produced by a conventional #6 dry cell. Show how a tiny spark may be produced by the dry cell when a wire is snapped against one of its terminals. Challenge the class to explain why the spark from the high voltage instruments is able to move so much further than the spark from the dry cell.

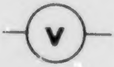
Development

1. Review the concept: An electric current is a flow of electrons. Encourage the class with questions, such as, "What makes the electron move?" Elicit the conclusion that something must be pushing

the electrons. The harder they are pushed, the farther they will move through the air surrounding the instruments shown.

2. Explain to the class that the force which makes the electrons move is called the electromotive force. Electromotive force is usually abbreviated EMF.

3. Set up a simple series circuit and measure the EMF of the dry cell. Allow a pupil to read the voltmeter and compare its reading with the printed voltage rating on the dry cell. Define the volt as the unit of EMF and then explain that the voltmeter is used to measure EMF.

4. Draw the symbol for the voltmeter on the board. 

5. Display a voltmeter that has several ranges. Have the pupils draw on their experiences in reading ammeters to account for the different numbers on the scales.

6. Have the pupils open their notebooks to the comparison of electric circuits and water pipes noted in previous lesson. Challenge them to explain what supplies the force in a system of water pipes (a pump), what supplies the force in an electric circuit (the dry cell), and what is similar to water pressure (EMF). Make sure the pupils enter these comparisons in their tables.

7. Set up a simple circuit with two dry cells in series. Have the class predict the total EMF of the two cells (3V). Measure the EMF to allow them to verify their predictions. Conclude that when dry cells are connected in series, the total EMF will be the sum of the EMF batteries.

8. Rewire the dry cells in parallel. Have the class predict the total EMF of this combination (1½volts). Measure the EMF and establish that when dry cells are wired in parallel, their total EMF remains the same.

Summary

1. What is the name of the force that makes the electrons move?
2. In what unit of measure is electromotive force counted?
3. What "pumps" the electrons in an electric circuit? In parallel?

Homework

1. Why doesn't the electricity in your house make large sparks in the electrical outlets?
2. What is the name of the instrument that is used to measure EMF?
3. Show how four dry cells could be connected to produce the following EMFS: 1½ volts, 3 volts, 4½ volts, 6 volts.

Materials

Induction coil and Jacobs Ladder
Tesla coil
2, #6 - 1½V dry cells
Voltmeter
Demonstration voltmeter
Miniature lamp in base
Assorted wires with clips

8. HOW CAN THE CURRENT IN AN ELECTRIC CIRCUIT BE INCREASED?

LABORATORY LESSON*

Outcomes

- When the EMF in an electric circuit is increased, the amount of current increases.
- When the resistance in an electric circuit is decreased, the electric current increases.

Motivation

Challenge the class to suggest ways to increase the amount of current in an electric circuit.

Development

1. Tell pupils that today's experiment will help find ways to increase the electric current in a circuit.
2. Distribute the equipment and Worksheets.

---

* May take two periods for completion

Homework

1. Answer questions 1-6 on your Worksheet.
2. Write a lab report based on today's experiment. Be sure to include neat, accurate drawings of all the electric circuits used.

(May be duplicated for use by pupils)

LABORATORY WORKSHEET—PHYSICS: LESSON 8

Problem: How can the current in an electric circuit be increased?

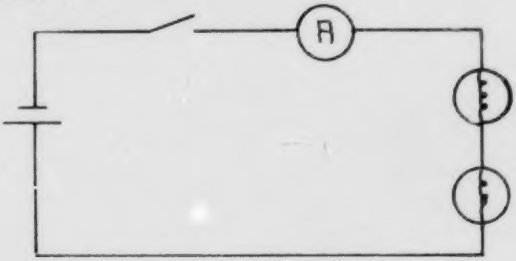
Materials

Ammeter
2, #6 dry cells
2 miniature lamp bases with 1½V bulbs
Switch
Assorted wires with clips

Procedure and Observations

(Be sure to have the teacher check your circuits before you close the switch.)

1. Set up this circuit:



   a. Be sure the ammeter is on the 0-3 range.

   b. Have the teacher approve your circuit.

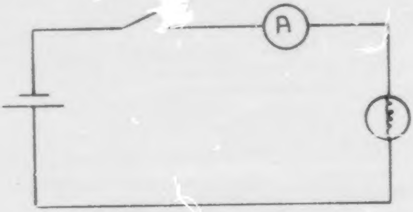
   c. Close the switch and record the reading of the ammeter and the brightness of the bulb.

   (If the ammeter needle moves in the wrong direction, reverse the wires connected to the dry cells.)

TABLE OF OBSERVATIONS

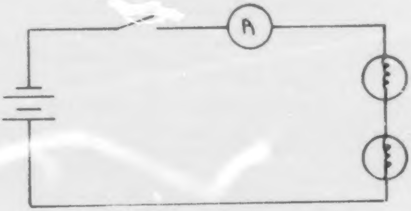
Dry Cells	EMF	Loads	Current	Lamp: Dim/Normal/Bright
1		2 lamps		
1		1 lamp		
2		2 lamps		
2		1 lamp		

2. Set up this circuit. (Remove one lamp from the circuit used in #1.)



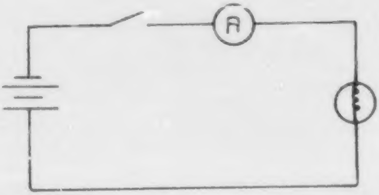
Close the switch and record the reading of the ammeter and the brightness of the bulb.

3. Set up the circuit. (Be sure the dry cells are connected in series.)



Close the switch and record the reading of the ammeter and the brightness of the bulb.

4. Set up the following circuits. (Remove a lamp from the circuit used in No. 3.)



Close the switch and record the reading of the ammeter and the brightness of the lamp.

Conclusions

Refer to your table of observations to answer the following questions:

1. What happened to the electric current in the circuits with 2 lamps when the EMF was increased from 1½V to 3V?
2. What happened to electric current in circuits with 1 dry cell when the number of lamps was decreased from 2 to 1?
3. What happened to the electric current when the EMF was doubled (from 1½V to 3V) and the resistance was also doubled?
4. How can the current in an electric circuit be increased?

   a.______________________________ b.______________________________

5. How can the current in an electric circuit be decreased?

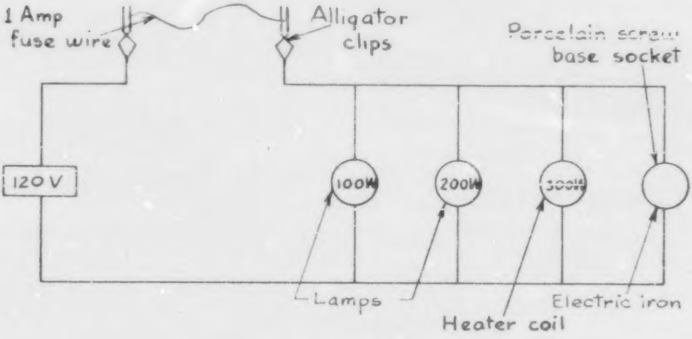
   a.______________________________ b.______________________________

6. How is it possible to increase the EMF in an electric circuit and not change the current?

REVIEW AND REINFORCEMENT (1—8)

NOTE: It is left to the instructor to select the most suitable of the following selections for review and reinforcement.

Parallel Circuits


1 Amp fuse wire
Alligator clips
Porcelain screw base socket
120 V
100W
200W
300W
Lamps
Heater coil
Electric iron

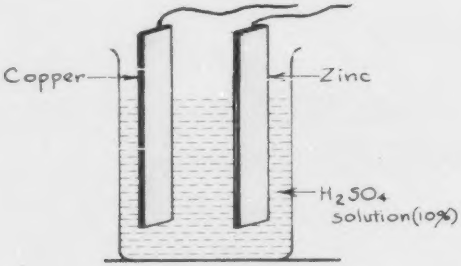
If wires carry too much current, they get warm or hot. "Octopus" circuits add parallel resistors, and extension cords get warm. Illustrate this with the demonstration on preceding page:

EMPHASIZE

1. Hiding cords under rugs may be dangerous because the heat of the cord may cause the kindling temperature of the rug to be reached.
2. Proper fusing is essential.
3. Extension cords must have wire thick enough to carry the current intended.

CURRENT AND VOLTAGE

Make a wet cell (zinc—copper).



Measure the current and voltage produced by the cell. Anticipate a voltage of about one volt with small currents.

Topics for Reports

Thomas Alva Edison
George Ohm
Andre Ampere
Alexander Volta
Benjamin Franklin

Problems

Show, with the aid of a circuit diagram, how you would wire the lights in a 3-room apartment.

MAGNETISM

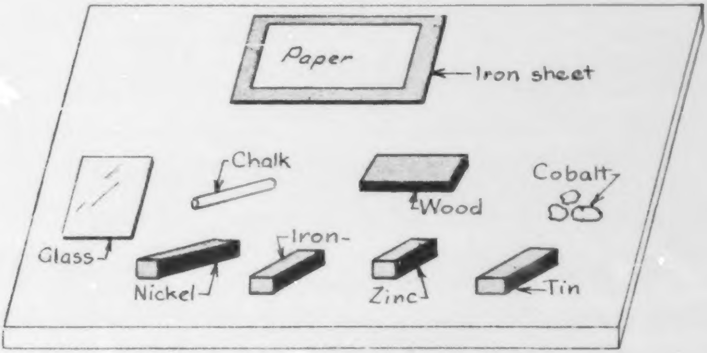
9. WHAT DO WE KNOW ABOUT MAGNETS?

Outcomes

- Magnetic materials include iron, nickel, and cobalt.
- Magnets are strongest at the poles.
- Like magnetic poles repel; unlike magnetic poles attract.
- Magnetism is not affected by nonmagnetic materials.

Motivation

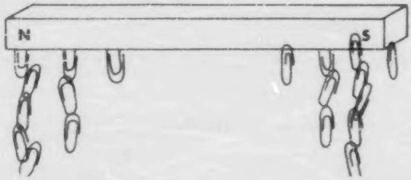
Place these materials on display:


Paper
Iron sheet
Chalk
Wood
Cobalt
Glass
Iron
Nickel
Zinc
Tin

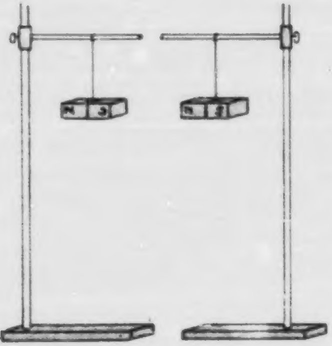
Challenge the class to predict which of the materials will be attracted to a magnet. Record their predictions on the board. Test their suggestions by placing a magnet near each object. The paper is placed over the iron sheet to emphasize the need for careful observation.

Development

1. From the motivation, identify three magnetic materials: iron, cobalt, nickel.
2. Challenge the class to suggest a method for finding out where magnets are strongest. One method is to place a set of paper clips in a row and lower a bar magnet on them. Most of the clips will be held at the ends of the magnet. Identify the places on a permanent magnet where the magnetism is strongest as the poles.



3. Ask the class to suggest a method to find what effect the poles of the magnets have on each other. One method is to suspend the magnets by threads and observe their behavior.

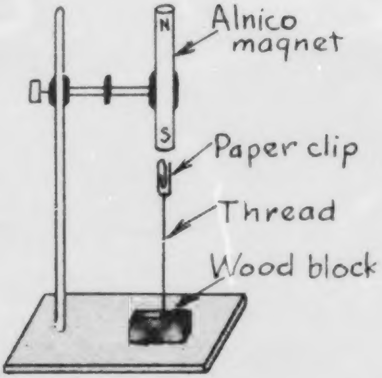


Caution: Make sure that the suspended magnets are at a sufficient distance from the ring stand to reduce the effect of the iron support on the magnet.

Label the poles of the magnets "north" and "south" and record how they affect each other.

Like poles (n-n, s-s) repel. Unlike poles (n-s) attract.

4. Set up this demonstration:



Place various materials listed in the motivation between the paper clip and the magnet to show that only iron, cobalt, and nickel affect magnetism.

5. *Display magnets of different strengths. Be sure to include an alnico magnet. Explain to the class that the strongest magnets are made of the metals aluminum, nickel, and cobalt. This mixture of metals (alloy) is called "alnico."*

Summary

1. Which metals are affected by magnetism?
2. Where are permanent magnets strongest?
3. What rules do magnetic poles follow?
4. Which metals affect magnets?
5. *What is alnico?*

Homework

1. Test a nickel (5¢) to see if it is made of nickel.
2. How can you use a pair of magnets to prevent a door from closing?
3. Investigate the kitchen of your home and report on how magnets are used as household aids.

Materials

Glass plate
Chalk
Paper clips
2 bar magnets
Iron stands with clamps
Thread
Alnico magnet
Wood block
Assorted magnets

Metals:

Nickel	(S-1, #10-7728)
Lead	(S-1, #10-76 38.01)
Iron	(from metal shop)
Zinc	(S-1, #10-7948a02)
Tin	(S-1, #10-7908)
Cobalt	(S-1, #10-7528)

10. HOW CAN MAGNETS BE CREATED AND DESTROYED?

LABORATORY LESSON

Outcomes

- We can make magnets by induction and by stroking magnetic materials with a strong magnet in one direction.
- A magnet can be destroyed by heating, hammering, or rubbing in many different directions with a strong magnet.

Motivation

Display several commercially made items containing magnets: toys, knife holders, etc. Challenge the class to explain how the magnets in these items were made. Today's lab will help answer this and other questions.

Development

Distribute Worksheets and materials.

Homework

1. Answer the questions on the Worksheet.
2. Write a report based on the experiments you did today.

Materials

Assorted commercially made items containing permanent magnets.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—PHYSICS: LESSON 10

Problem: How can magnets be created and destroyed?

Materials

3 pieces of steel wire	Wood block
Alnico magnet	Hammer
Alcohol lamp	Paper clips
Pliers	Soft iron nail

Procedure and Observations

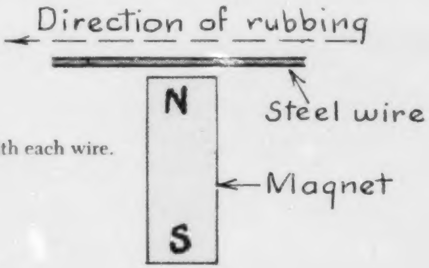
1. Try to pick up the paper clips with the iron nail. Now place the alnico magnet near the nail (but not touching it) and try again to pick up the clips.

   Is the nail magnetized?

   Is the nail permanently magnetized?

   Magnetism produced this way is called *induced* magnetism.

2. Rub the three pieces of steel wire about 30 times on one end of the magnet. Make sure you rub in only one direction.



   Try to pick up the paper clips with each wire.

   Were the wires magnetized?

3. Take one of the magnetized wires and rub it vigorously in *both* directions with the magnet. Test it for magnetism with the paper clips. Record your observations.

   NOTE: Be sure that the paper clips are not already magnetized by testing to see if they attract other objects, e.g., other paper clips.

4. Holding the second magnetized wire with the pliers, heat it for about three minutes in the flame of the alcohol lamp. Test the wire for magnetism and record your observations.
5. Place the third wire on the wooden block and strike it repeatedly with the hammer. Test the wire for magnetism and record your observations.

Conclusions

1. Describe two ways to change nonmagnetic iron into magnetic iron.
2. Describe three ways to demagnetize iron (destroy its magnetism).
3. How can you magnetize a pair of scissors?
4. How can you demagnetize a screwdriver?

11. HOW MAY WE EXPLAIN MAGNETISM?

Outcomes

- It is believed that magnets consist of small parts or domains, each of which has magnetic properties.
- A magnet is produced when the domains are properly aligned.
- Disarranging the domains destroys the magnet.

Motivation

Display a 4″ length of magnetized steel wire. Use a demonstration compass needle to show that it has north and south magnetic poles. (An unmagnetized length of wire will attract both poles of a compass needle. This may be demonstrated.) Challenge the class by asking, "Can a magnet be demagnetized by cutting it into small pieces?"

NOTE: Repulsion is a test for magnetism.

Development

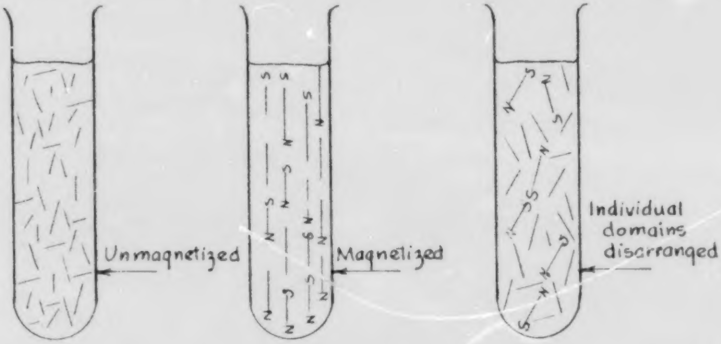
1. Cut the magnetized wire into two equal parts and have a pupil test each part with the compass. Divide each half of the wire again and have a member of the class test each piece for magnet-

ism. Elicit the fact that if we continue to cut the wire into smaller and smaller pieces, each piece is still a magnet. The smallest part that would be a magnet is called a domain. Write *domain* and its definition on the board.

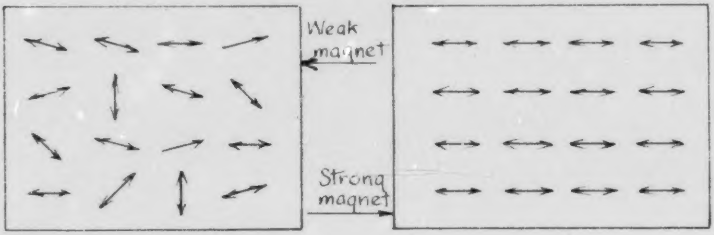
2. Fill a small test tube half full of iron filings. Ask the class to imagine that each individual iron filing is a domain. Have a pupil test the test tube of iron filings for magnetism.

3. Review methods of producing magnetism. Have a pupil magnetize the tube of iron filings by stroking it about thirty times, in one direction, with an alnico magnet.

4. Have a pupil test the tube of iron filings for magnetism. Shake the tube of filings thoroughly and have it tested again. Challenge the class to explain the results of the experiment. During the discussion, an enlarged drawing of the test tube may be useful.



5. Use a commercial magnet model to reinforce the concept that when magnetic domains are arranged in an orderly fashion, magnets are stronger than when their arrangement is not orderly.



6. *Challenge the class with the question, "Do you think there is a limit to the strength of an iron magnet?" When the domains are perfectly aligned, the magnet has reached its maximum strength.*

Summary

1. What is a magnetic domain?
2. What must be done to the magnetic domains to produce a magnet?
3. Why does striking a magnet destroy its magnetism?

Homework

1. Two bars of iron are the same size and shape. One of the bars is a strong magnet, the other a weak one. With the aid of a diagram, explain how this is possible.
2. Explain how a compass is used to tell whether or not a bar of iron is a magnet.

Materials

Magnetized steel wire (4″)	Iron filings
Demonstration compass	Small test tube with cork
Model of a magnet (S-1, 14-1668)	

12. WHAT IS A MAGNETIC FIELD?

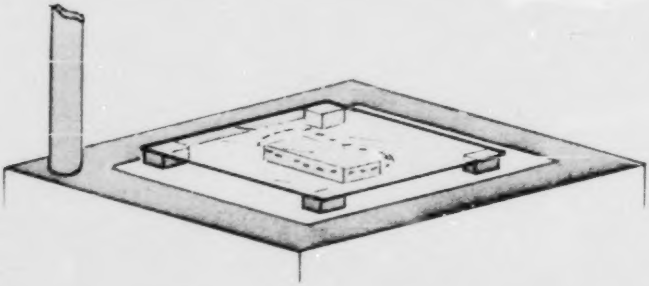
LABORATORY LESSON

Outcomes

- The space around a magnet is different from ordinary space.
- Lines of force are concentrated at the poles of a magnet.

Motivation

Place a bar magnet on the stage of an overhead projector; cover the magnet with a sheet of acetate supported by small blocks. Sprinkle iron filings over the sheet to show the magnetic field of the bar magnet. Tap the celluloid sheet lightly to show how this improves the alignment of the iron filings. Identify the lines formed as "lines of force."



Development

1. Tell the students that they will investigate the space around different magnets and groups of magnets in today's laboratory lesson.
2. Distribute Worksheets and materials.

CAUTION: Small objects or powders, such as iron filings, should be used carefully to avoid getting them into pupils' eyes.

Homework

1. Write a report based on today's experiment. Include drawings of all the magnetic fields you investigated.

Materials

Overhead projector
Acetate sheet
Bar magnet
Iron filings
Small wood blocks

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—PHYSICS: LESSON 12

Problem: What is a magnetic field?

Materials

5 x 8 index card
Saltshaker containing iron filings
Small wooden blocks to support index card
2 bar magnets
1 horseshoe magnet

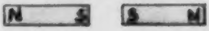
Procedure and Observations

1. Using the method your teacher demonstrated, investigate the following magnetic fields:

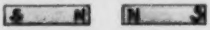
   1 bar magnet

   1 horseshoe magnet

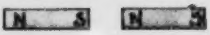
   2 bar magnets ½" apart—south poles facing each other



   2 bar magnets ½" apart—north poles facing each other



   2 bar magnets ½' apart—north pole facing south pole



   NOTE: Make a drawing of each field you investigate and pour the iron filings back into the shaker after each investigation.

Conclusions

1. Why can a horseshoe magnet lift more than a bar magnet of equal magnetic strength?
2. How does the magnetic field of the south-south pole combination differ from the north-south pole arrangement?
3. How can you tell from the pictures of the magnetic field whether the magnets are attracting or repelling each other?
4. Where are the lines of force of a magnet concentrated?

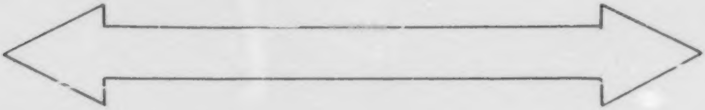
13. WHY DOES A COMPASS NEEDLE POINT IN A NORTHERLY DIRECTION?

Outcomes

- The earth acts as a huge magnet.
- Magnetic compasses respond to the earth's magnetic field.
- Magnetic compasses must be isolated from magnetic materials to operate properly.

Motivation

Distribute small compasses and paper arrows to each group of two pupils. Ask the class to place the compass on top of the paper arrow and then to turn the arrow until it is pointed in the same direction as the compass needle.



Development

1. Ask the class to make as many observations as possible concerning the direction that the arrows are pointing in. The following may be observed:
   a. All arrows point in the same general directions.
   b. Generally, the arrows point in the north-south direction.
   c. Some arrows are out of line.

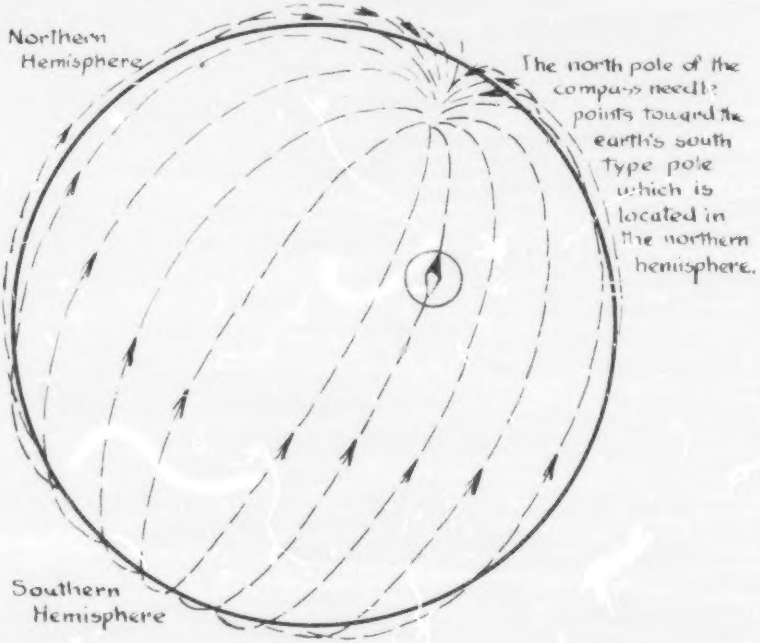
   The class's observations should be listed on the chalkboard.

2. Challenge the class to account for their observations. To develop explanations, you might demonstrate the effects of a magnet and a piece of iron on a magnetic compass.

OBSERVATIONS	EXPLANATIONS	DEMONSTRATION
All the compass needles point in the same general direction.	The earth acts as a huge magnet.	Hold a bar magnet over a large demonstration compass and observe the alignment of the needle.
The compass needles are pointing in a north-south direction.	The earth has north and south magnetic poles.	Show how the south pole of a compass points to the north pole of a magnet.
Some arrows are out of line.	Iron, cobalt, and nickel placed near a compass will disturb the magnetic needle.	Hold some iron near a large compass.

Summary

1. With the aid of this diagram, review how the earth acts like a huge magnet. Note that the magnetic pole of the north does not coincide with the geographic North Pole.


Northern Hemisphere
The north pole of the compass needle points toward the earth's south type pole which is located in the northern hemisphere.
Southern Hemisphere

Homework

1. Explain why a magnetic compass needle does not point to the geographic North Pole.
2. What condition must be present on Mars to make possible the use of a magnetic compass?

Materials

Paper arrows	Bar magnet
Magnetic compass	Demonstration compass

14. HOW CAN WE MAKE A MAGNET WITH ELECTRICITY?

Outcomes

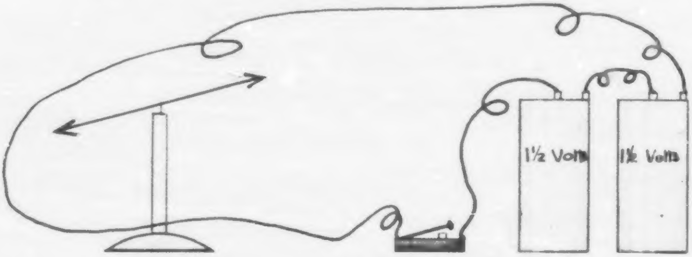
- A wire carrying an electric current is surrounded by a magnetic field.
- *The polarity of an electromagnet depends on the direction of the current.*

Motivation

Tell the class that in 1819 a Danish professor named Oersted made a very important discovery. Explain that you are going to duplicate the experiment that he did and that they are to see if they can explain what Oersted discovered.

Development

1. Make a large loop (about 15″ diameter) of bell wire. Connect this loop to a switch and two dry cells connected in series. Center a large demonstration compass *in the plane of the wire.*



For each of the demonstrations have the pupils list their observations:

DEMONSTRATION	OBSERVATION
Close switch	Compass needle moves
Open switch	Compass needle returns to its original position.

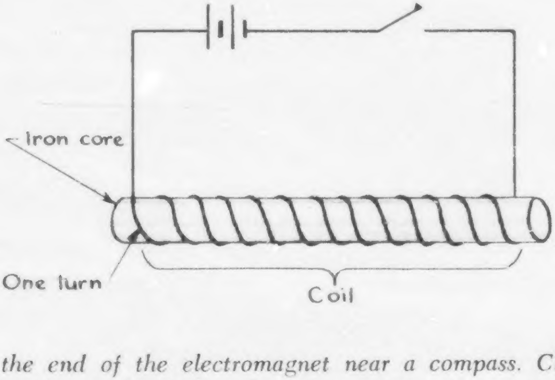
2. Challenge the class to think of a scientific explanation for their observations. Assist them in thinking through the series of events as follows:

   a. When the switch is closed an electric current flows.
   b. While the current is flowing, the compass needle is disturbed.
   c. The compass responds to magnetic fields and forces.
   d. The electric current is causing a magnetic field.
   e. When the current stops, the magnetic field should stop.
   f. This actually happens, and the needle returns to its original position.

3. Help the class generalize from this demonstration that when an electric current flows, a magnetic field is created. This is what Oersted's experiment showed.

4. Explain how the electromagnet is based on the above principle. Construct a coil of about 30 turns of bell wire. Connect the electromagnet in series with a switch and two dry cells. Open and close the switch to show how the magnetism of an electromagnet can be turned on and off. Add an iron core and repeat the demonstration.

5. Diagram the electromagnet on the board and label its parts.



6. *Place the end of the electromagnet near a compass. Close the switch and record which end of the compass is attracted to the magnet. Reverse the direction of the electric current (reverse the wires on the dry cell). Repeat the experiment and challenge the class to draw conclusions. When the electric current is reversed, the polarity of the magnet is reversed.*

Summary

1. What did Oersted discover about electricity and magnetism?
2. What are the parts of an electromagnet?
3. *What happens to the polarity of an electromagnet when the electric current is reversed?*

Homework

1. What advantage does an electromagnet have over a permanent magnet?
2. Draw a labeled diagram of an electromagnet with 10 turns.
3. *An electromagnet attracts the south pole of a compass. How can you make the electromagnet attract the north pole without moving the compass on the magnet?*

Materials

2, #6 dry cells
Demonstration compass
Switch
Iron core
Bell wire

15. HOW CAN WE MAKE AN ELECTROMAGNET STRONGER?

Outcomes

- Increasing the number of turns increases the strength of an electromagnet.
- Increasing the current in the coil increases the strength of an electromagnet.
- Increasing the amount of iron in the core increases the strength of an electromagnet.

Motivation

Display a small electromagnet (about 20 turns and 1 dry cell).

Explain to the class how wrecked automobiles and other large piece of scrap iron are lifted by electromagnets. Challenge them to sugges ways that an electromagnet can be made stronger.

Development

1. List the class's suggestions on the board. After each suggestion ask the class to give ways of testing each suggestion.

   NOTE: Do not accept suggestions, such as "make it large." Afte responses of this type, ask "How?", "What part?", "Wha materials do you need?"

2. Among the suggestions the following should be elicited:
   a. Increase the number of turns
   b. Increase the current
   c. Enlarge the core.

   Have the pupils come to the front of the room and prepare electro magnets to test the various suggestions. You can test the strengt of the magnet by counting the number of paper clips it will pic up and hold. A table such as the one below may be developed:

Electromagnet	Dry Cells	Core (Nails)	No. of Clips Picked Up		
			1st	2nd	Average
20 turns	1	1			
40 turns	1	1			
20 turns	1	1			
20 turns	2	1			
20 turns	1	1			
20 turns	1	4			

3. Encourage the class to draw conclusions based on the experimen The following should be developed and listed:
   a. Increasing the number of turns increases the strength of a electromagnet.
   b. Increasing the voltage increases the current in the coil an increases the strength of an electromagnet.

c. Adding iron to the core increases the strength of an electromagnet.

4. Display dismantled bells, buzzers, loudspeakers, etc., and identify the electromagnet in each one.

Summary

State 3 ways to increase the strength of an electromagnet.

Homework

1. Find 3 electromagnets in use in your home. Explain what each one does.
2. Is a permanent magnet useful for moving scrap iron? Why?
3. Two electromagnets are identical in all respects except that one is wound with thick copper wire and the other with thin copper wire. Which one will be the stronger magnet? Why?

   HINT: Look back into your notes on the resistance of wires.

Materials

Paper clips
Assorted bells, buzzers, loudspeakers, etc.
2, #6 dry cells
2 soft iron nails

16. HOW CAN A MAGNET BE USED TO MAKE AN ELECTRIC CURRENT?

LABORATORY LESSON

Outcomes

- When a magnet moves inside a coil of wire, an electric current is induced.
- The induced current may be increased by moving the magnet through the coil more quickly.

- The direction of the induced current depends on: a) polarity of the magnet; b) direction the magnet is moving.

Motivation

Challenge the class: "Why is a large available supply of electric current needed?" The discussion that follows should indicate the need for a source of electricity other than dry cells.

Development

1. Demonstrate the operation of a hand generator. Tell the pupils that today's lesson will help them learn how the generator operates.
2. Distribute Worksheets and materials.

Homework

Write a report based on today's experiment. Be sure to include your table of observations and your conclusions.

Materials

Hand generator

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—PHYSICS: LESSON 16

Problem: How can a magnet be used to make an electric current?

Materials

Coil of wire with 50 turns
Alnico magnet
Galvanometer (center needle type)

Procedures and Observations

1. Connect the coil of wire to the galvanometer. Using an alnico magnet, try to generate a current in the coil.
   NOTE: The galvanometer is a very sensitive, delicate type of ammeter. Handle it with great care.

2. The following experiments are done by moving the magnet back and forth in the coil of wire. Perform these experiments and record your observations:

Experiment			Galvanometer Reading	Direction of Deflection
N	P	in rapidly		
O	O	in slowly		
R	L	at rest in coil		
T	E	out rapidly		
H		out slowly		
S	P	in rapidly		
O	O	in slowly		
U	L	at rest in coil		
T	E	out rapidly		
H		out slowly		

Conclusions

1. How is an electric current made without using a dry cell?
2. How is the electric current induced in the coil increased?
3. Give two ways to change the direction of the induced current.
4. Under what conditions will a magnet and a coil produce no electric current?
5. *An alternating current is one that changes direction repeatedly. How can you use a magnet and coil to produce an alternating current?*
6. *Investigate the effects of*
   - *a. increasing the number of turns of the coil*
   - *b. using a stronger magnet*

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17. HOW CAN ELECTROMAGNETISM BE USED TO INDUCE ELECTRICITY?

Outcome

- Moving magnetic fields may induce electric currents in nearby coils.

Motivation

Recall from previous lessons how an electromagnet was made. Elicit from the pupils that the flow of current in a coil of wire induced a magnetic field around the core.

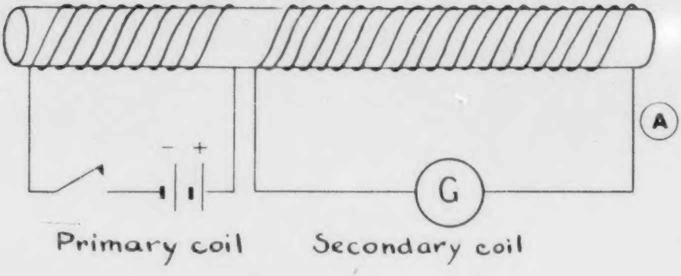
Development

Construct and display the apparatus in diagram A which follows. Call attention to the insulation on the wires and to the fact that there is no direct connection between the electric circuits. Close the switch and challenge the class to account for the momentary current in the secondary circuit.

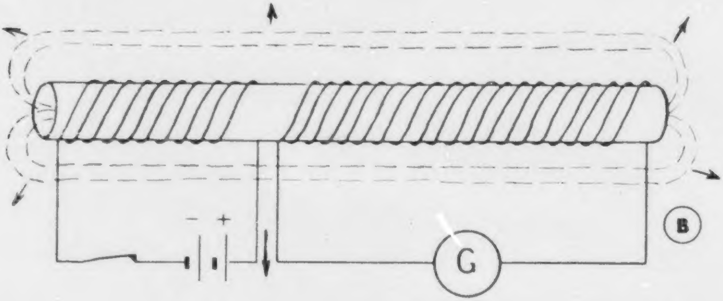
1. Draw a labeled diagram of the apparatus. Identify the primary circuit as the one with the source of electric current (dry cells) and the secondary circuit as the one with the induced current.
2. Allow the class time to advance theories to account for the momentary current induced in the secondary circuit. During this discussion the need for further investigation should arise. If it does not, ask the class to suggest additional experiments with this apparatus. The following should be included in the suggestions:

INVESTIGATION	GALVANOMETER READING	DIRECTION OF DEFLECTION
Open circuit		
Close switch		
Closed switch		
Open switch		

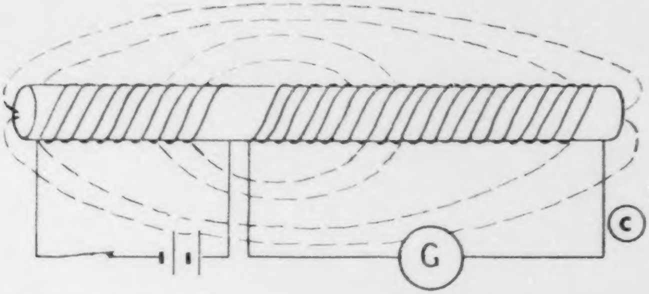
3. The following analysis of the behavior of the circuit may be elicited:
   a. Open circuit
      1) No current in the primary circuit
      2) No magnetic fields present
      3) No current in the secondary circuit



b. Close the switch
  1) Electric current flows in the primary circuit.
  2) A magnetic field begins to form around the iron core.
  3) The magnetic field is moving outward.
  4) The moving magnetic field induces a current in the secondary coil.
  5) The galvanometer records the momentary current in the secondary coil.

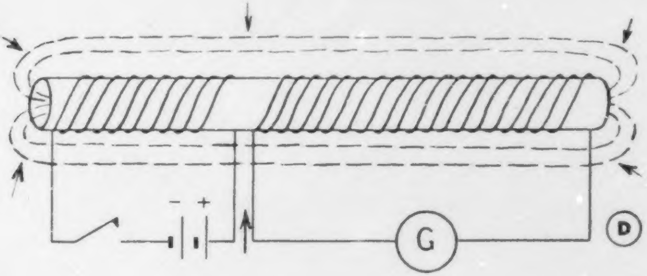


c. Closed circuit
  1) A steady current is flowing in the primary circuit.
  2) The magnetic field around the core is fully developed and is no longer growing or moving.
  3) Since there is no moving magnetic field, there is no induced electric current in the secondary circuit and the galvanometer has returned to zero.



d. Open the switch
  1) The current in the primary circuit stops.
  2) The magnetic field around the core moves inward (collapses).
  3) The moving magnetic field induces a current in the secondary circuit.
  4) Since the magnetic field is now moving inward instead of outward, the momentary electric current should also change direction.
  5) The galvanometer records the predicted current.

NOTE: Stress the fact that each time the switch is opened and closed the cycle is repeated; demonstrate this.



Summary

1. Repeat the original demonstration and ask the class to retrace the steps of the explanation.
2. How can an electric current be induced in a secondary coil?

Homework

1. Define primary coil and secondary coil.
2. What happens in the secondary coil when the switch in the primary coil is closed? Why?
3. Why was the galvanometer needle deflected only when the switch was opened and closed?

Materials

Large galvanometer with a zero center
Soft iron core
Bell wire
2, #6 dry cells
Switch

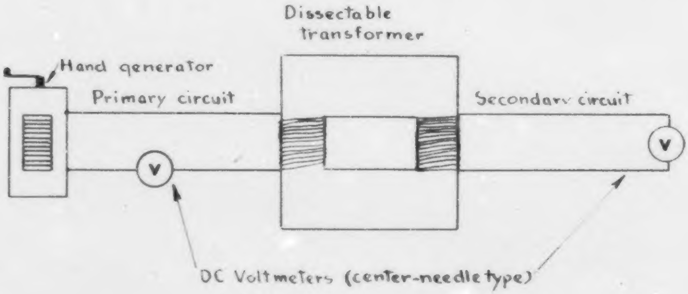
18. HOW DOES A TRANSFORMER WORK?

Outcomes

- Transformers operate on alternating current.
- The induced voltage in a transformer is related to the number of turns on each coil.

Motivation

Set up the following circuit:


Dissectable transformer
Hand generator
Primary circuit
Secondary circuit
V
V
DC Voltmeters (center-needle type)

Identify the parts of the circuit and call attention to the fact that the transformer is similar to the induction coil used in the previous lesson.

Review quickly the conditions under which a voltage is induced by a magnetic field. Challenge the class with this question: "Since there is no switch in the primary circuit, will a voltage be induced in the secondary circuit when the hand generator is turned?"

Development

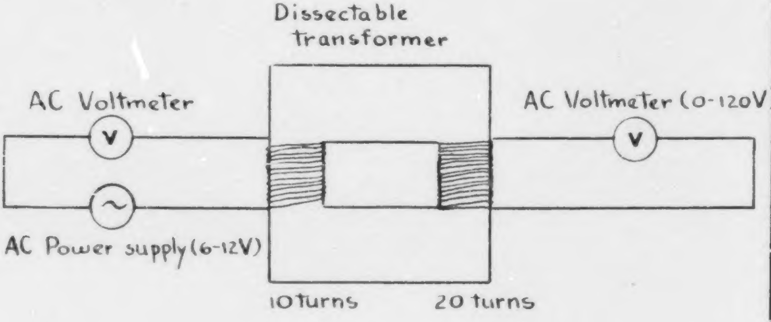
1. After a short discussion call a pupil and have him turn the hand generator *slowly*. Ask the class to record their observations; have a pupil keep a record of the results on the board.

2. Call attention to the movement of the voltmeter in the primary circuit. Point out that it moves back and forth, showing that the voltage and current are always changing. Elicit that the continually changing current leads to a continually changing or moving magnetic field. This moving magnetic field induces a voltage in secondary circuit.

3. Identify the changing current in the primary circuit as alternating current or AC.

4. Repeat the demonstration and review the items No. 1 - 3.

5. Set up the following apparatus:



Draw a labeled diagram of the apparatus on the board.

6. Use various combinations of coils on the dissectible transformer to illustrate that different combinations of turns give different voltages in the secondary circuit. Introduce the idea of a turns ratio. The following chart may be useful.

PRIMARY VOLTAGE	SECONDARY VOLTAGE	NUMBER OF TURNS IN THE PRIMARY	NUMBER OF TURNS IN THE SECONDARY	TURNS RATIO

Turns ratio = number of turns in the secondary divided by the number of turns in the primary.

7. Establish the generalization that the turns ratio tells how much the transformer multiplies the voltage.

Summary

1. How does AC differ from the direct current obtained from a dry cell?
2. Demonstrate the spark from a Tesla coil. Ask the class to use what they learned today to explain how it steps up 110V AC to 20,000V DC.

Homework

1. The doorbell in most homes operates on 6V, but the house current is approximately 120V.
   a. What instrument is used to change 120 volts into 6 volts?
   b. What should the turns ratio be?

2. A transformer has a turns ratio of 1:1. If the voltage in the primary circuit is 7 volts, what is the voltage in the secondary circuit?

Materials

Dissectible transformer (S-1, 14-2028)
2 DC voltmeters, center needle type (0-120V)
2 AC voltmeters, (0-120V)
Hand generator
AC power supply (6-12V)
Assorted wires

NOTE: When measuring currents and voltages, always begin the measurements using the highest range available on the instrument.

REVIEW AND REINFORCEMENT (9—18)

NOTE: The instructor may select the most suitable of the suggestions for review and reinforcement.

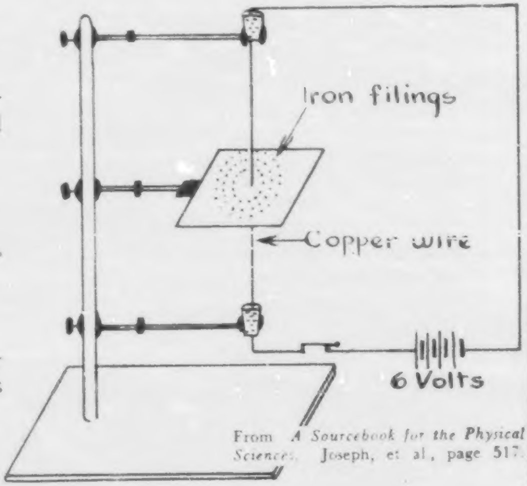
Demonstrations

1. Show the magnetic field around a conductor.

   Review:

   a. Lines of force

   b. Whenever electrons move, a magnetic field is created.



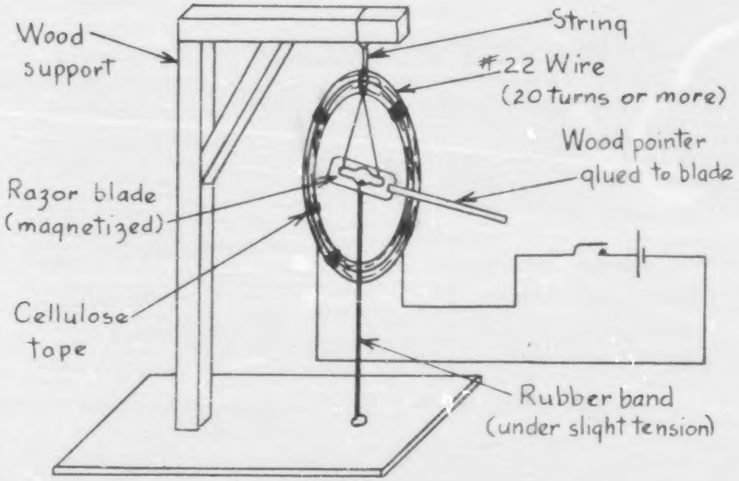
From *A Sourcebook for the Physical Sciences*, Joseph, et al, page 517.

2. Dip the ends of two cylindrical alnico magnets into iron filings. Bring like poles within 1½″ and unlike poles to the same distance. The pupils will see a three-dimensional representation of the magnetic fields. They will unify their concepts of lines of force, magnetic fields, and laws of poles.

3. Make a demonstration galvanometer.

   Sources:

   Part III, NYS *General Science Handbook*, #3220
   S-1, 14-2058
   O.K. Magnetism Kit (Reference: Unit EM 521, 550)


Wood support
String
#22 Wire (20 turns or more)
Wood pointer glued to blade
Razor blade (magnetized)
Cellulose tape
Rubber band (under slight tension)

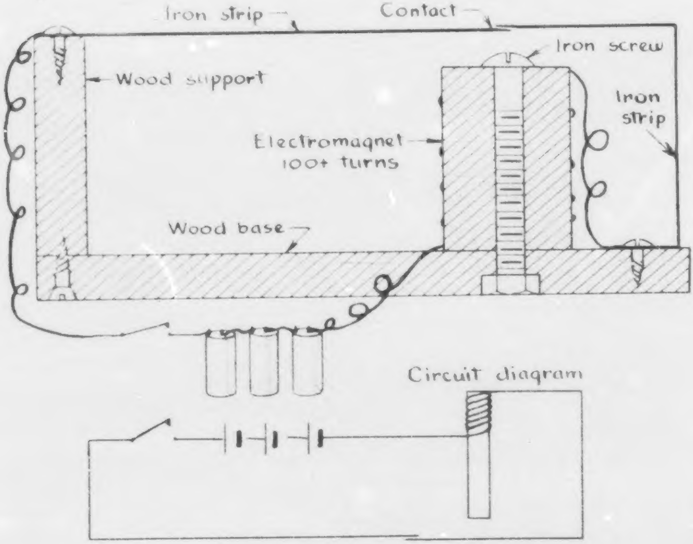
Have students recall their experiences using ammeters and voltmeters and have them locate electromagnets in dismantled meters, if available.

Films (BAVI)

Magnetism (13 min.)	*Magnetism and Electricity* (17 min.)
Magnetism (11 min.)	*Story of Magnetism* (20 min.—color)

Project

Build an electric buzzer. Adjust the buzzer for maximum performance by adjusting the gap between the contacts and the top of the electromagnets.


Iron strip
Contact
Iron screw
Wood support
Iron strip
Electromagnet
100+ turns
Wood base
Circuit diagram

HEAT

19. HOW DOES HEAT AFFECT THE SIZE OF MATTER?

Outcome

- When matter is heated, it usually expands.

Motivation

Demonstrate the ball and ring apparatus:

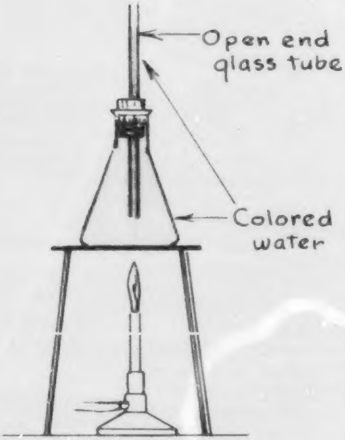
1. Show that the ball will fit through the ring.
2. Heat the ball in the flame of a Bunsen burner and try to pass the ball through the ring.
3. Plunge the ball into water and try to pass it through the ring.

Development

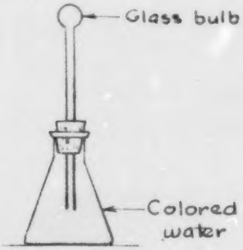
1. Challenge the class to explain why the ball fit through the ring when it was cold, but not when it was hot.
2. Write the conclusion "Solids expand when they are heated" on the board. Ask the question, "Should we consider any other states of matter?" From the discussion that follows, the importance of testing both liquids and gases should arise.
3. Set up the apparatus shown: (See next page.)

   Heat the flask over a Bunsen burner. As the colored water is heated, it will expand and rise in the tube. Develop the generalization: liquids expand when they are heated.

(See Development No. 3)



4. Set up the apparatus shown:



Have a pupil place his hand on the bulb. As the warmth of his hand heats the air in the bulb, it will expand and force the colored water down the tube. From this elicit the generalization that "gases expand when heated."

5. *Demonstrate the bimetallic strip. Tell the class that it is composed of two different metals welded together. Challenge them to account for the bending of the strip when it is heated.*

   Relate its use in the thermostat and fire alarm systems.

Summary

1. How can we show that solids expand when heated?
2. What happens to liquids when they are heated?
3. What happens to gases when they are heated?

Homework

1. Why are cracks left between the blocks of concrete in sidewalks?
2. What happens to air when it is heated?
3. Why does the mercury in a thermometer expand when the thermometer is heated?
4. How can you use the bimetallic strip to turn a heater on and off?

Materials

Ball and ring apparatus	Dye (colored ink)
Flask	Bunsen burner
Assorted rubber stoppers	Tripod with wire gauze
Glass tube with a bulb end	Bimetallic strip
Glass tube (24″)	

20. HOW IS TEMPERATURE MEASURED?

Outcomes

- Thermometers use uniformly expanding materials to measure temperature.
- Fahrenheit and Celsius (centigrade) are two common thermometer scales.

Motivation

Prepare and label three battery jars of water:

Jar A, temperature 130° F (Check to ascertain that water is lukewarm before letting pupils *test* for temperature.)
Jar B, room temperature
Jar C, temperature 40° F

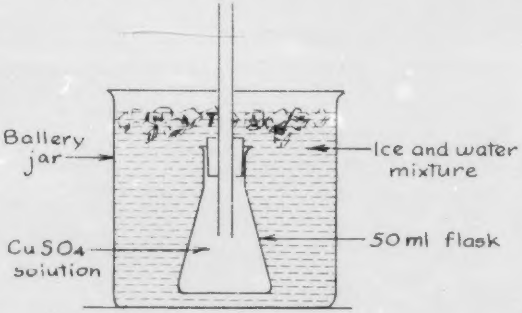
Have a pupil carefully test with fingertip, the temperature in Jar A and Jar B and report on the temperatures. Ask him then to place one hand in Jar B and the other in Jar C and once again report his impressions of the relative temperatures.

Development

1. Allow several other pupils to repeat this procedure. The variety of their reports should illustrate the need for a more reliable and accurate means of temperature measurement.
2. Fill a small flask (50ml) with a concentrated solution of copper sulfate ($CuSO_4$): Place a one-hole rubber stopper with a long glass tube in the flask. Ask the class how this apparatus could be

used to measure temperature. A method such as the following may be developed:

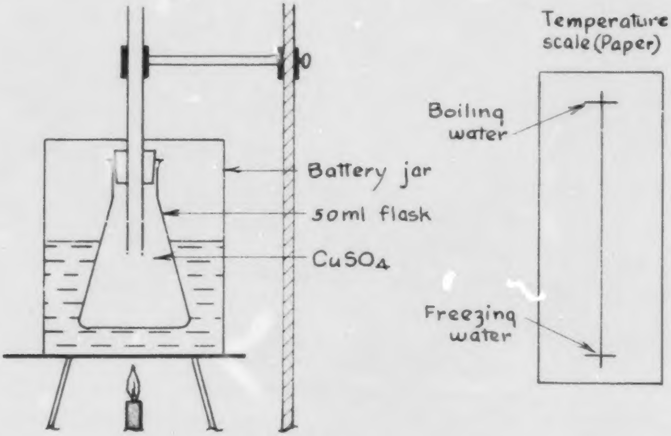
a. Fill one large pyrex beaker or battery jar with an ice-water mixture. Immerse the flask with tube in the jar and stir mixture. Observe the drop in water level.


Ballery jar
Ice and water mixture
CuSO4 solution
50 ml flask

b. When the water level has stopped falling, mark the glass tube.

c. Place a pyrex battery jar on a tripod; heat it to boiling with a Bunsen burner. Carefully immerse the flask in the boiling water. Observe the rise in water level. When the water level has reached its maximum height, mark the tube.

d. Measure the distance between the marks and transfer this distance to a paper scale.


Battery jar
50ml flask
CuSO4
Temperature scale (Paper)
Boiling water
Freezing water

3. Tape the paper scale to the glass tube. Pose the question, "Have we finished constructing our thermometer?" From the discussion that follows the need for smaller divisions on the scale should be developed. In the Fahrenheit temperature scale, the freezing point of water is called 32° and boiling is labeled 212°. There are 180 divisions or degrees between the freezing and boiling points of water. In the Celsius (centigrade) system the freezing point of water is labeled 0° and the boiling point 100°. Most scientific measurements are made in the Celsius (centigrade) system. Label the paper scale accordingly.

4. Display the following thermometers and identify the expanding material in each case:
   a. the water thermometer (just constructed)
   b. oven thermometer
   c. mercury thermometer
   d. alcohol thermometer

5. Immerse the flask and tube (water thermometer) in a jar of water at room temperature. Estimate the temperature with the water thermometer and check the accuracy with a mercury thermometer. Use both Celsius and Fahrenheit for the estimates.

Summary

1. On what principle is the operation of thermometers based?

2. What is the freezing point of water in the Fahrenheit system? In the Celsius system?

Homework

1. Alcohol freezes at *—115°C* and mercury at *—39°C*. Which would be best to use in a thermometer to measure very low temperature? Why?

2. How many degrees are there between the boiling point of water and the freezing point of water in the Fahrenheit system? In the Celsius system?

3. Suppose you had a mercury thermometer with no markings on it (no scale); how would you go about making a scale for it?

Materials

2 pyrex battery jars
50ml flask
One-hole stopper
Long glass tube
Iron stand with clamp
Wax pencil
Concentrated copper sulfate solution
Bunsen burner
Oven thermometer
Alcohol thermometer
Mercury thermometer
Tripod
Wire gauze

21. WHAT IS HEAT?

Outcomes

- Heat is a form of energy.
- The amount of heat in a substance is due to the motion of all its molecules.

Motivation

Demonstrate Stoekle's Tube to show how mercury molecules increase their velocities when heated.

Heating the mercury causes its molecules to gain so much energy that when they strike the blue glass beads in the tube they cause them to move vigorously. Once the beads have begun to jump the tube may be removed from the heat. The action will continue for a short period.

Development

1. After demonstrating Stoekle's Tube, challenge the class to explain why the glass beads jump when the tube is heated. You may wish to review the concept "all matter is made of atoms and molecules."

   During the discussion of the molecular vibration apparatus (Stoekle's Tube) the following observations and conclusions should be developed:
   a. Energy is needed to make the blue beads jump.
   b. The tube is being heated.

   c. As the tube cools, the beads stop jumping.
   d. Heat is making the beads jump.
   e. Heat is a form of energy.

2. Display a hammer and a strip of lead. Ask the class to think of a way to test the aforementioned conclusions, using the hammer and lead. If the lead is pounded with the hammer, it warms. Reinforce the relationship between heat and energy by restating the conclusion that heat is a form of energy in which the molecules are moving. The energy of movement may cause objects to heat.

3. Demonstrate Stoekle's Tube again. Explain that as the mercury absorbs heat energy, its molecules begin to move faster. When the mercury becomes very hot, its molecules move so fast that they cause the glass beads to jump when the molecules hit them. Draw a diagram on the board to illustrate this concept.

4. Ask a pupil to bend a wire back and forth until it breaks and then report the temperature of the wire before and after bending. Have the class explain why the wire became warm when it was subjected to repeated bending.

5. *Ask the class to compare the movement of molecules in materials at high temperature with their movement in materials at low temperature. Explain and encourage discussion of the lower limit of temperature, i.e., when the molecules have almost stopped moving. This is the lowest possible temperature and is called absolute zero. It is −459° on the Fahrenheit scale and −273° on the Celsius scale.*

Summary

1. Hammer a nail halfway into a board. Pull the nail out with the claw end of a hammer. Have the class summarize the lesson by using the concepts developed to account for the heating of the withdrawn nail.

Homework

1. Explain why the blue beads jumped when the mercury in Stoekle's Tube was heated.

2. What happens to the molecules in your hand when you rub them together several times? Try it.

3. Why is it necessary to cool machinery having parts that rub against each other?
4. *Why is it that there is a lowest possible temperature?*

Materials

Stoekle's Tube (S-1 #14-0188)	Wire hanger
Bunsen burner	Nails
Clamp	Lead strip
Hammer	Wood block

22. HOW DOES HEAT TRAVEL?

Outcomes

- Heat travels through empty space by radiation.
- Heat travels through matter by conduction.

Motivation

Expose a radiometer to a source of radiant energy. (Use sunlight, if possible; otherwise use another strong source of light.) Allow the class to observe the motion of the rotating vane. Ask, "What causes the vane to spin?"

Development

1. Show that it is the sun's energy which causes the radiometer to rotate. Show that blocking the sun's light causes the rotation to stop.
2. Demonstrate the rod conductometer (#14-0908). Ask the class to advance theories to account for the movement of heat through the various metals.

   A short review of the previous lesson "What is heat?" may aid them in developing the idea that as the molecules at one end of a material get hot and begin to move faster, they strike the molecules near them and so the heat energy travels along the material. This process should be defined as conduction.

3. By observing that the wax beads on the conductometer melt at different times, the class may conclude that some materials are better conductors of heat than others.

   Copper and silver are among the best conductors of heat.

4. Test the ability of air to conduct heat. Hold a wooden safety match near the edge of the flame from a Bunsen burner, and notice that it will not ignite. This shows that air is a very poor conductor of heat. Diagram the demonstration on the board and have the class write their observations and conclusions.

5. Test the ability of water to conduct heat; fill the bottom of a test tube with cracked ice. Place a weight, such as a brass nut, on top of the ice. Fill the tube half full of water. Support the test tube with a clamp and direct the flame of a Bunsen burner to the upper portion of the test tube. The water at the top of the tube will boil before the ice at the bottom melts. Diagram this demonstration on the board and have the class write their observations and conclusions.

Summary

1. How does heat energy travel from the sun to the earth?
2. How does heat travel by conduction?
3. What types of materials conduct heat best?

Homework

1. What would the earth be like if heat were not able to travel by radiation?
2. Why is it that you can bring your hand very close to a flame without being burned?
3. Why is it that the whole stove becomes hot when the oven is lit?

Materials

Radiometer
Light source
Conductometer—5 rod, 14-0908
Paraffin
Bunsen burner
Wooden matches
Test tube
Iron stand with clasp
Brass nut (use as small weight)
Ice

23. HOW DOES HEAT TRAVEL BY CONVECTION?

Outcome

- Heat travels through liquids and gases by the process of convection.

Motivation

Set up and demonstrate the convection box. Challenge the class to explain why smoke is drawn down one of the chimneys and rises in the other one.

Development

1. On the chalkboard, draw a carefully labeled diagram of the convection box. Trace the smoke through the apparatus and show it on the diagram, making note of what is happening at each point. A sequence, such as the following, may be developed.

   a. The candle heats the air.
   b. Warm air is pushed up by adjacent cooler air.
   c. The chimney on top of the candle allows the warm air to be pushed out of the box.
   d. Cool air enters the other chimney to take the place of the warm air that has been pushed out.

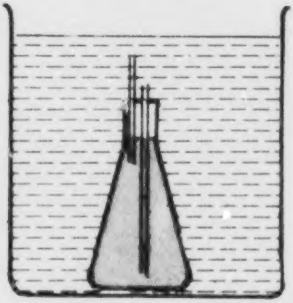
   Explain, based on the preceding demonstration, that the hot air leaving the box takes the heat with it. Define this method of heat movement as convection.

2. Perform the following demonstration to show convection currents in a liquid:

   a. Fill a battery jar with cold water.
   b. Fill a small flask with hot water to which coloring matter has been added.
   c. Place a two-hole rubber stopper with a long tube and a short tube into the neck of the small flask (see illustration).
   d. Submerge the flask with the rubber stopper into the battery jar.

   Follow the movement of the water as convection currents begins.

   Develop a sequence of steps explaining the demonstration.



3. Ask the class to think of instances in which heat travels by convection. The following may be cited:
   a. Hot air rising from a radiator
   b. Hot air rising from the pavement in the summer
   c. Hot water rising from the bottom of a pot on the stove
   d. Cold water moving to the bottom of a lake or ocean.

Summary

1. Why does the smoke move downward in the demonstration of the convection box?
2. Why did the colored liquid move to the top of the battery jar in the demonstration of convection of liquids?

Homework

1. Why is it best to ventilate a room by opening both the top and bottom of a window?
2. Why are the oceans coldest at the bottom?
3. Why does water in a pot begin to move when you heat it?

Materials

Convection box
Battery jar
Hot water, color added
Cold water

Flask (25-50ml)
2-hole rubber stopper to fit flask
Glass tubing—1 long, 1 short

24. HOW IS HEAT MEASURED?

LABORATORY LESSON

Outcomes

- Heat may be measured in metric system units called calories.
- One calorie is the amount of heat required to raise the temperature of one gram of water one degree Celsius.

Motivation

Review how temperature is measured. Explain that the temperature is an indication of how much heat energy a body has. Challenge the class to think of a method to measure heat. Today's laboratory problem will help the class to understand how heat is measured.

Development

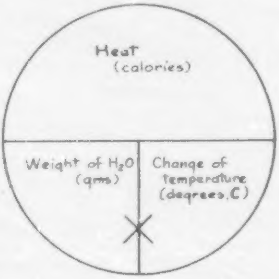
1. Display a graduated cylinder. Weigh it alone and with various amounts of water in it to establish that one ml of water weighs one gram.
2. Define the calorie as the amount of heat required to raise the temperature of one gram of water one degree Celsius.
3. Distribute the Worksheets and materials.

Homework

1. Write a report based on the work you did today. Be sure to include all your calculations, diagrams, and answers to the questions on the Worksheet.

Materials

Graduated cylinder
Triple beam balance
Water



(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—PHYSICS: LESSON 24

Problem: How is heat measured?

Materials

Thermometer (Celsius)	Alcohol burner
Graduated cylinder (500 ml)	Water
Beaker (500 ml)	Matches
Tripod	Timer (wristwatch or clock)
Wire gauze	

Procedures and Observations

NOTES: We will use one ml of water as equal to one gram of water.

—— One calorie is the amount of heat required to raise the temperature of water one degree Celsius.

1. Pour 100 grams of water into a beaker. Measure its temperature. Heat it for 5 minutes and measure its temperature again. Record your observations on the table.
2. Repeat the experiment, using 200 grams of water. Record your observations.
3. If time permits, repeat the experiment with 400 grams of water. Record your observations.

AMOUNT OF WATER (GRAMS)	TEMPERATURE AT START (DEGREES CELSIUS)	TEMPERATURE AFTER 5 MIN. (DEGREES CELSIUS)	CHANGE IN TEMPERATURE (DEGREES CELSIUS)	HEAT GAINED (CALORIES)
100				
200				
400				

4. Calculate the heat gained (calories added to) by each quantity of water. To help you find the heat gained use the problem solver. (See opposite.)

HEAT = MASS × CHANGE IN TEMPERATURE

With your hand, cover the quantity that you want to find. The problem solver will tell you what to do to find it. For example, if you want to find the heat, cover that part of the problem solver with your hand; the way to find the heat is to multiply the weight of water by the change in temperature. To find the change in temperature, the problem solver tells you to divide the heat by the weight of water.

Conclusions

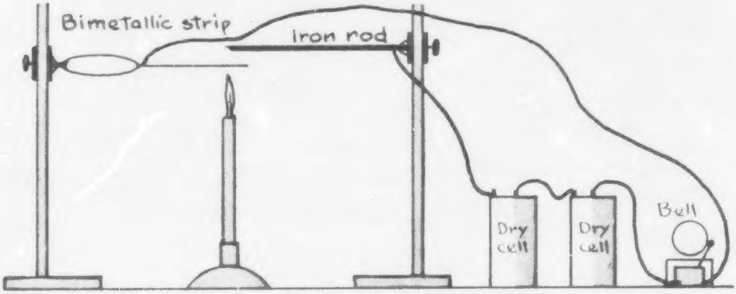
1. How many calories did the water gain when it was heated for 5 minutes?
2. What is the effect of doubling the amount of water heated?
3. How much heat does the alcohol burner give the water in 5 minutes? How much heat is produced per minute?
4. Do you think all the heat energy of the alcohol burner goes into the water? Explain.
5. How much heat energy is needed to heat 100 grams of water (not ice) from 0°C to 100°C?

REVIEW AND REINFORCEMENT (19—24)

The instructor may select the most suitable of the following suggestions for review and reinforcement.

Demonstrations

1. Demonstrate the operation of the thermograph. Call attention to the metal thermometer and review this concept: materials expand when heated.
2. Show how the bimetallic strip mav be used as a thermostat.



3. Display a vacuum or thermos bottle. By showing the means by which the vacuum bottle retards the flow of heat energy, review conduction, convection, radiation.

Reports

1. Cryogenics
2. Absolute Zero
3. Thermostats
4. The Heat Energy or Caloric Content of Food
5. Thermal Pollution

Films (BAVI)

Learning About Heat (8 min.)

Nature of Heat (11 min.)

Conversion of Heat to Useful Work (15 min.)

Heat—Its Nature and Transfer (11 min.)

SUGGESTED UNIT EXAMINATION: PHYSICS

The following are not intended as a diagnostic tool or a comprehensive measure of the outcomes of the unit. The teacher may use them for review purposes or as a source for a unit examination.

Multiple Choice

1. An electric current is a flow of electrons from
   a) negative to positive
   b) positive to negative
   c) negative to negative
   d) positive to positive

2. In a series circuit, the electrons have
   a) many paths to follow
   b) two paths to follow
   c) one path to follow
   d) high voltage

3. Parallel circuits
   a) permit independent operation of electrical devices
   b) draw less current from the source
   c) are used only with lamps
   d) are not as good as series circuits

4. In normal house wiring, electrical outlets are connected in
   a) parallel circuits c) short circuits
   b) series circuits

5. A substance through which electrons will not flow easily is called a
   a) conductor c) metal
   b) insulator d) magnet

6. Which of the following will not affect the resistance of a wire?
   a) the length c) the nature of the metal
   b) the thickness d) the insulation

7. A voltmeter
   a) is more easily damaged than an ammeter
   b) does not have much resistance
   c) is connected in series with the rest of the circuit
   d) is connected in parallel with the rest of the circuit

8. Ammeters
   a) can never be connected to a high voltage circuit
   b) should be connected across a battery
   c) are used only in parallel circuits
   d) should be connected in a series with the rest of the circuit

9. The voltage rating of a single dry cell is
   a) 1½ b) 3 c) 6 d) 110

10. If the EMF or voltage in a circuit is increased, the
    a) current will remain the same c) current will decrease
    b) current will increase d) resistance will decrease

11. A generator is a device for producing
    a) heat energy c) electrical energy
    b) light energy d) thermal energy

12. All parts of a series circuit have the same
    a) length b) voltage c) resistance d) current

13. A magnetic material is
a) copper b) gold c) cobalt d) zinc

14. Strong magnets are made of
a) nickel b) copper c) alnico d) lead

15. A magnet may be destroyed by
a) heating b) freezing c) sunlight d) loud noises

16. The lines of force of a bar magnet are
a) affected by copper c) concentrated at the center
b) not touching the poles d) concentrated at the poles

17. The motion of a compass needle indicates that the
a) earth acts as a huge magnet c) sun has a magnetic field
b) earth is spinning d) moon has a magnetic field

18. When the north pole of bar magnet approaches a piece of brass, the end of the brass nearest the magnetic
a) becomes a north pole c) remains unaffected
b) becomes a south pole d) is attracted

19. A bar magnet is broken into four equal parts. The number of magnets produced is
a) 2 b) 4 c) 6 d) 8

20. Electromagnetism is associated with
a) molecules b) electrons c) protons d) neutrons

21. To increase the strength of an electromagnet
a) increase the current through it
b) use a nichrome coil
c) decrease the applied voltage
d) increase the resistance

22. When a magnet moves in a coil of wire
a) the magnet becomes weaker
b) the poles of the magnet are reversed
c) an electric current is produced in the wire
d) the resistance of the wire is decreased

23. To reverse the polarity of an electromagnet
a) increase the voltage c) decrease the voltage
b) increase the current d) reverse the current

24. To increase (step up) the voltage, the turns ratio of a transformer should be
a) 2:1 b) 1:1 c) 1:2 d) 1:0

25. Heat is a form of
a) energy b) force c) power d) temperature

26. Heat can cause changes in
a) length c) temperature
b) molecular motion d) all of these

27. All Fahrenheit thermometers have
a) 100° between freezing and boiling points of water
b) 180° between freezing and boiling points of water
c) mercury
d) alcohol

28. Energy from the sun reaches the earth by
a) conduction b) convection c) radiation
d) all of these

29. When a body is heated, the molecules
a) contract c) move more slowly
b) move close together d) move faster

30. A compound bar (bimetallic strip) bends when it is heated because the metals of which it is made
a) expand at different rates c) do not expand
b) expand at the same rate d) contract

31. The rising column of smoke, from a smokestack, is mainly due to
a) conduction b) convection c) radiation d) induction

32. Solids transfer heat by the process of
a) conduction b) convection c) radiation d) induction

33. The Celsius (centigrade) equivalent to 32° F is
a) −40° b) 0° c) 32° d) 100°

34. The number of calories required to raise the temperature of one gram of water one degree Celsius (centigrade) is
a) 1/16 b) 1 c) 10 d) 100

35. Thermometers measure
a) heat b) temperature c) calories d) power

Matching

Place the letter of the term that best matches the statement in the column on the right.

a. Parallel circuit
b. 32° F
c. Calorie
d. Ammeter
e. AC
f. 0° F
g. Dry cell
h. Transformer
i. Voltmeter
j. Switch
k. Series circuit

1. Measures EMF ------
2. Measures electric current ------
3. Reverses itself ------
4. Unit of heat energy ------
5. One path for electrons to follow ------
6. Several paths for electrons to follow ------
7. Increases voltage ------
8. Opens and closes electric circuits ------
9. Source of EMF ------
10. Freezing point of water ------

Completion

From the following terms, select the one that best completes the statements:

increases *decreases* *remains the same*

1. As resistance increases, electric current ----------

2. As voltage decreases, resistance ----------.
3. As the current is decreased, the strength of an electromagnet ----------.
4. As molecular motion decreased, temperature ----------.
5. As the temperature increases, the size of matter ----------.

Essay

1. A series circuit with three lamps was constructed. The followin resulted from experiments with the circuit

Voltage		*Current*	
	3V		1 amp
	6V		2 amps
	9V		3 amps
	12V		0 amps

   a. How can you explain the current for 12 volts?
   b. What do you think the current would be for:

   1½ volts 4½ volts 7½ volts

2. A student in science laboratory was trying to increase the strengt of an electromagnet by increasing its current. He recorded th following results:

Current		*Clips Picked Up*	
	⅒ amps		1
	⅕ "		2
	1 "		10
	2 "		20
	3 "		22
	4 "		22
	5 "		22

   How can you explain his results?

3. As matter is heated, its molecules move faster. How can this fa be used to explain why matter expands when it is heated?

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Unit III

BIOLOGY

Materials of Life

The Needs of Living Things
Cells
Nutrition

159/160

NEEDS OF LIVING THINGS

Suggested Lessons and Procedures

1. HOW CAN WE TELL LIVING FROM NONLIVING THINGS?

Outcomes

- Living things carry out a variety of life activities, such as taking in food, digestion, respiration, circulation, excretion, response to stimuli, growth, and reproduction.
- Both plants and animals are living things and carry out life processes or activities.
- *Many nonliving things were once living things or the products of living things.*

Motivation

Exhibit these items or substitutes:

- Snail in test tube
- Mealworm in test tube
- Goldfish in beaker of water
- Pebble
- Plastic insect
- Potted plant
- Picture of animal
- Beaker of water

Ask volunteers to come up and arrange these objects in two groups—*living* and *nonliving*.

Pose the question, "How do we know which objects are alive?"

Development

1. Elicit from pupils the reasons why they placed objects in a particular group. List and briefly discuss the following characteristics for grouping the *living* objects.

    a. Respiration — Breathing
    b. Digestion — Changing food to a form the body can use
    c. Ingestion — Taking in food; eating
    d. Response to stimuli — Use examples (body senses; plant responses to light and food)
    e. Reproduction — Use examples (seeds, plants, living things)
    f. Excretion — Getting rid of waste materials (refer to bathroom routines)
    g. Locomotion — Moving from place to place
    h. Circulation — Transporting materials throughout the system
    i. Growth — Forming new living material

2. Guide pupils to understand that living things carry on certain basic life processes or activities. Elicit from pupils how some of the living specimens carry out various life processes. Discussion can be stimulated by the following questions:

    How does the fish move through the water?

    How is the movement of the snail different from the movement of the fish? How do fish breathe?

    How does the fish respond when we tap the beaker?

3. Pose the question, "Do plants carry out life activities?" Briefly discuss growth of plants, reproduction by seeds, response to light. Elicit that plants also carry out many of these life processes.

    (The life processes of plants will be covered in a later lesson.)

4. *Exhibit a seashell, a sheet of paper, a piece of fur, and a fossilized animal or plant. Pose the question, "Are these living things?" Elicit that many things which appear to be nonliving are actually products of living things or were at one time alive.*

Summary

1. How are the life processes of a dog different from the life processes of a cockroach?

2. How do we carry on life processes?
3. Why are human beings considered to be animals?

Homework

1. Make a list of 6 living things.
2. Compare how each of these living things carries out any 2 life activities.

Materials

Snail in test tube
Mealworm in test tube
Goldfish in beaker of water
Beaker of water
Plastic insect
Picture of animal
Potted plant
Pebble
Seashell
Sheet of paper
Piece of fur
Fossilized animal or plant

2. HOW DOES THE MICROSCOPE HELP US TO STUDY LIVING THINGS?

LABORATORY LESSON

Outcomes

- The various parts of the microscope work together to enable us to see objects that cannot be seen with the naked eye.
- Proper handling of the microscope involves the correct use of each part.

Motivation

1. Arrange pupils in small groups and distribute a hand lens to each group.
2. Instruct one member of each group to remove a hair gently from his own head and let the group examine it.
3. Now ask the group to examine the hair under the magnifying lens. How does it appear different? Elicit that it appears larger and some of its details may be seen.

4. Pose the question, "Can this hair be examined to reveal its fine structure in detail?" Elicit that a microscope is a tool that can be used to enlarge objects so as to see them in greater detail.

Development

1. Distribute to each group of pupils a Worksheet and a duplicated diagram of a microscope showing the parts of the microscope. (See opposite.)
2. Identify the parts of the microscope for the class. Have them point out the parts on their own microscopes.
3. Following the instructions outlined on the Worksheet, have pupils prepare a slide of the letter "e."
4. Summarize, using the questions at the end of the Worksheet.

Homework

1. Why is it important to use only lens paper to wipe off the lenses?
2. What special care must be taken when focusing with the fine adjustment knob?
3. In order to move an object in the field of the microscope to the left and up, in which direction must the slide be moved?

Materials

Hand magnifying lens
Chart showing parts of the microscope
Typewritten "e" on 1″ sq. white paper

Slide
Lens paper
Cover slip

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—BIOLOGY: LESSON 2

Problem: How does the microscope help us to study living things?

Materials

Microscope
Slide

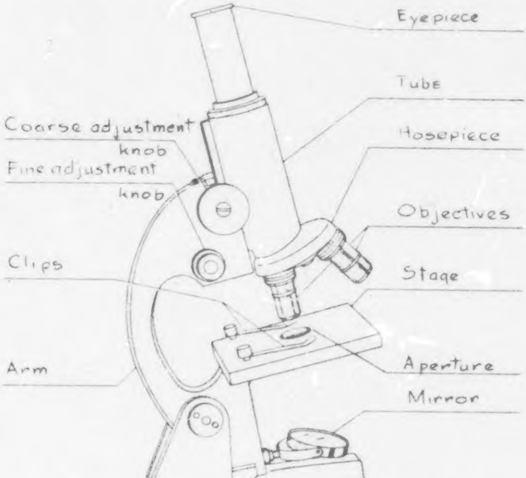
Coverslip
Lens paper

Magnifying lens
Letter "e"

(MAY BE DUPLICATED FOR USE BY PUPILS)

THE PARTS AND USE OF THE MICROSCOPE

1. Study the picture of the microscope carefully.
2. Notice that the microscope has two lenses mounted in a tube to provide ease of viewing. Some microscopes have more than two lenses. What is the purpose of the lenses?
3. The lens at the top of the tube is called an eyepiece.
4. The lenses at the bottom of the tube are called the objectives and are mounted on the nosepiece.
5. The knobs on the side of the tube are for raising and lowering the tube.
6. Under the nosepiece is a platform to hold the object you wish to examine. This is called a stage. A hole in the stage directly under the nosepiece allows light to pass through the object. Why is this important?
7. Below the stage is a mirror that reflects light through the hole in the stage. Why is it important that the mirror be kept clean?
8. The object that you are going to examine is placed on a little piece of glass called a slide.


Eyepiece
Tube
Coarse adjustment knob
Nosepiece
Fine adjustment knob
Objectives
Clips
Stage
Arm
Aperture
Mirror

Procedure and Observations

1. Always hold and carry the microscope with both hands, one on the arm and the other below the base.

2. Gently clean the slide, eyepiece, objectives, mirror, and opening in the stage with lens paper. Before cleaning, blow gently across these surfaces to remove any dust particles which might scratch them.

3. How can you identify the low-power objective? Swing the low-power objective into position. How can you tell when it is in place?

4. While watching it from the side, lower the tube using the coarse adjustment knob, until the low-power objective reac[illegible] bottom, without touching anything. Why should you carefully watch the tube as it is lowered?

5. Look under the stage. You should be able to see the diaphragm. Make sure the diaphragm is wide open. Why do you think this is important? What number is the diaphragm set at?

6. Look through the eyepiece with one eye. Keep both eyes open. Carefully tilt the mirror until you see a very bright circle of light. Why should this be the brightest possible circle of light?

7. Place the square of paper (on which the letter "e" is typed) on the slide, right side up. Carefully place a cover slip over the paper. Draw a diagram showing the letter "e" on the slide.

8. Place your slide on the stage and make sure the letter "e" is directly over the opening in the stage. Place the clips on either end of the slide to hold it securely on the stage.

9. While looking through the eyepiece, focus upward slowly, using the coarse adjustment knob. Never focus downward. Why?

10. Stop when the object appears in focus, and then use the fine adjustment knob to sharpen the focus.

11. Draw a diagram of the letter "e" as it appears under the microscope. Do you notice any change? Describe any differences in its appearance.

12. Move the slide to the right. In which direction does the "e" appear to move? Move the slide to the left. In which direction does the "e" move?

13. Move the slide up. In which direction does the "e" appear to move? Move the slide down. In which direction does the "e" appear to move?

Conclusion

1. Fill in the following chart:

DIRECTION OF MOVEMENT	
Slide Moved	Object in Field of Microscope Moves
Towards left	
Towards right	
Upward	
Downward	

2. How does the microscope aid us in examining small objects?

3. WHAT CAN WE SEE IN A DROP OF POND WATER?

LABORATORY LESSON

Outcomes

- There are many living things which cannot be seen except by the use of a microscope.
- There are small parts of living things which cannot be seen except by the use of a microscope.
- Life processes of tiny plants and animals can be studied under the microscope.

Motivation

Show the class a sample of pond water or hay infusion culture. Pose the question, "How can we find out if the sample contains living things?" Elicit that the microscope is a tool which can be used to explore the sample to see what it contains.

Note: Artificial pond water or hay infusion can be made by placing some organic matter from a lake or pool, a lettuce leaf, or some hay, in an open jar of water and letting it stand outdoors for about 24 hours. Several days after bringing it indoors, microorganisms should be present.

Development

1. Divide the class into small groups. Distribute laboratory materials and Worksheets.
2. Show pupils how to prepare a slide of the pond water culture. Methyl cellulose may be added to slow down the movement of the microorganisms. Demonstrate the proper technique of placing a cover slip on a slide.
3. Direct pupils to prepare a slide of the pond water. Have pupils examine the slide under the low power objective of the microscope.
4. Have pupils focus their specimens under high power.
5. Instruct pupils to draw diagrams of several of the microorganisms. Tell pupils to draw some of the tiny structures inside the microorganisms which the microscope reveals.
6. Summarize, using the questions at the end of the Worksheet.

Homework

1. Why is it inadvisable to drink water from lakes and ponds?
2. How do you know that the microorganisms seen under the microscope were living things?

Materials

Pond water culture or hay infusion culture

Microscopes

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—BIOLOGY: LESSON 3

Problem: What can we see in a drop of pond water?

Materials

Microscope
Hay infusion or pond water culture
Slide

Coverslip
2 toothpicks
Lens paper

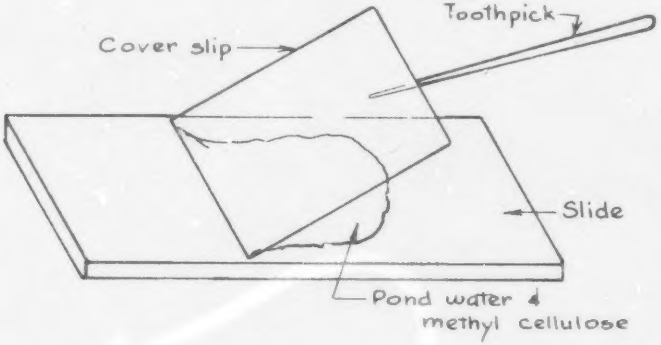
Methyl cellulose

Procedure and Observations

1. Focus your microscope, following the same directions you used in the lesson when you examined the letter "e".
2. Prepare a slide of pond water. Use a medicine dropper to place a drop of pond water on your slide.

   To observe living things in detail, it is necessary to slow down their motion. Use a toothpick to mix a small drop of methyl cellulose with the material on the slide.

   Touch one end of a cover slip to the material on the slide and support the opposite end with a toothpick. (See diagram.) Carefully lower the cover slip to the slide, so that no air bubbles are caught under it.



3. Place the slide on the stage under the low power objective. Focus upward slowly with the *coarse* adjustment knob. Stop when the object is in focus and sharpen the image with the *fine* adjustment knob. What do you see? How many different kinds of living things do you see?
4. Swing the high power objective into place, making sure it does not hit the slide. Use the *fine* adjustment knob only to sharpen the focus.
5. Draw diagrams of several of the living things as they appear under high power. Can you see any internal structures? Draw them on your diagrams.

Conclusions

1. What life processes did you see carried out on your slide?
2. Describe a structure which was a means of locomotion for one of the micro-organisms you observed.
3. Why is the microscope an important tool for scientists?

4. WHAT ARE THE NEEDS OF LIVING THINGS?

Outcome

- Plants and animals have basic needs, such as food, water, air, and a proper environmental temperature in order to carry on life activities.

Motivation

Exhibit a potted geranium plant. Ask pupils if they have any potted plants at home. Pose the question, "What would happen to these plants if you left them unattended for a long time?" Elicit that the plants will die if they are not supplied with water. Guide pupils to conclude that living things must be supplied with materials to meet certain basic needs and that water is but one of them.

Development

1. Show pupils pieces of bread, one of which has been refrigerated for several days and the other unrefrigerated in a shallow dish of water until mold forms on it. Ask why the refrigerated bread has no mold on it. Elicit that the mold will not grow unless there is a suitable temperature. Freezing or cooling provide an environmental temperature unsuitable for growth. Another of the basic needs of living things is a proper environmental temperature. How does an excessively high temperature affect living things?
2. Discuss food needs of pets or other animals. Elicit that some living things need a specialized diet because of their dentation.
3. *Discuss the diets of some living things.*

    Beaver—bark from tree
    Mosquito—blood
    Panda—bamboo shoots
    Woodpecker—insects
    Lion—meat
    Horse—green plants
    Bear—almost anything

    Elicit that some animals eat a very limited diet while others exist on a varied diet. Identify animals which eat plants as herbivores, meat eaters as carnivores, and animals which eat plants and meat as omnivores.
4. Ask what the needs of astronauts are. Elicit that oxygen must be supplied. Oxygen is another basic need of all living things.

Summary

1. What are the needs of living things?
2. How are astronauts supplied with the basic needs?

Homework

1. How does canning food preserve it against the growth of bacteria?
2. How does drying food preserve it against the growth of bacteria?

Special preparation for Lesson 5

As part of the lesson, have the pupils participate in setting up these preparations.

1. Cover a geranium plant with a plastic bag and tie the open end of the bag securely around the stem of the plant. Place the plant in the sun or under a bright light. Elicit from the pupils that the inside of the bag is dry.
2. Add brom thymol blue to aquarium water in a test tube with a growing sprig of Elodea or other aquarium plant. Set up another test tube without a plant, as a control. Stopper both tubes and cover them with black paper or put them in a dark place until the next lesson. Have pupils note the color of the solutions.
3. Cut one-half inch from the bottom of a stalk of celery. Half fill a beaker with water and add a colored dye or ink. Place the stalk of celery in the beaker so that it stands upright. Store this in the sunlight until the next lesson.

Materials

Potted geranium plant
2 pieces of bread, one moldy
2 test tubes
Rubber stoppers
Colored dye
Beaker
Sprig of Elodea or other aquarium plant
Black paper
Stalk of celery
Plastic bag
Brom thymol blue

5. HOW CAN WE STUDY THE LIFE ACTIVITIES OF PLANTS?

Outcomes

- Plants carry on the life activities of breathing and circulation.
- The life activities of plants are similar to the life activities of animals.

Motivation

1. Have a pupil come up and exhale through a straw into brom thymol blue. The brom thymol blue turns yellow. This indicates that carbon dioxide (CO_2) is present in the air we exhale.
2. Have another pupil exhale on the chalkboard. Pupils can observe moisture on the chalkboard. Elicit that water vapor is also present in the air we exhale.
3. Further elicit that carbon dioxide and water are eliminated from the body during respiration, one of the life activities of all animals.

Development

1. Call attention to the plastic-covered plant, set up in Lesson 4. Have pupils make careful observations of the interior of the bag. Elicit that the water droplets on the inside of the bag are produced by the plant.
2. Have pupils observe the test tubes of Elodea set up in Lesson 4. Have pupils note that the test tube of brom thymol blue containing the Elodea plant has turned yellow. Elicit that the green plant is producing carbon dioxide.
3. Guide pupils to understand that the carbon dioxide and water vapor produced by the plants are the same as the products eliminated during respiration in animals. Elicit that plants also carry out the life activity of respiration.
4. Have pupils observe the celery demonstration set up in Lesson 4. Elicit that the absorption of ink by the celery stalk is a process similar to the life activity of circulation in animals.

5. *Discuss some of the other life activities of plants:*
    a. *Reproduction—production of seeds*
    b. *Growth*
    c. *Response to stimuli—tropism: turning or growth toward light, gravity, or water*
    d. *Ingestion—Insect-eating plants like the sundew, Venus's-flytrap, or pitcher plant.*

Summary

1. What are the products of respiration in animals?
2. What are the products of respiration in plants?
3. How are the life activities of plants similar to the life activities of animals?

Homework

1. Make a list of the life activities of a plant.
2. How are materials transported between the roots and leaves of a plant?

Materials

Brom thymol blue
Drinking straw
Test tube
Geranium plant covered with plastic bag (set up in previous lesson)
Test tube containing Elodea and brom thymol blue
Test tube containing brom thymol blue
Stalk of celery in beaker containing ink or dye

REVIEW AND REINFORCEMENT (1—5)

NOTE: It is left to the teacher to select the most suitable of the following suggestions for review and reinforcement.

Reports

Pupils may report on the contributions of scientists in the field of microscopy.

Anton von Leeuwenhoek
Matthias Schleiden
Theodore Schwann
Robert Hooke
Robert Brown
Louis Pasteur
Robert Koch

Growing Living Things at Home

NOTE: For most of these activities, use a jar with a wide mouth, such as a one-pint peanut butter or mayonnaise jar.

Observe and record changes that occur during growth and development.

GROWING BREAD MOLD

Obtain a wide-mouthed jar. Cut blotters or paper toweling in circles to fit bottom of the jar and moisten it. Sprinkle some dust on a piece of bread and place it on the moist paper. Cover the jar loosely and set it in a warm place. Examine the bread daily for the white cottony growth of bread mold. Observe the changes that occur.
NOTE: See caution regarding molds, bacteria, and yeasts.

CULTURING BACTERIA

Crush a dozen dried lima beans and place them in a wide-mouthed jar half-filled with water. Do not cover the jar for about one day. Keep it in a warm, dark place. After a day, cover the jar.

GROWING YEAST

To a wide-mouthed jar, add about one inch of water in which has been dissolved about two teaspoonfuls of sugar. Mix in about one-quarter teaspoonful of yeast. Cover the jar and keep it in a warm, dark place. Find out the role of yeast in making bread and wine.

GERMINATING SEEDS

Line the inside of a wide-mouthed jar with a blotter or paper towel.

Between the glass and the paper, place about five seeds halfway up from the bottom of the jar. You may use lima beans, after soaking them in water for 24 hours, radish seeds, or any other kind of fast-growing seeds. Pour about one-half inch of water into the bottom of the jar. Do not cover.

GROWING PLANTS FROM PARTS OF PLANTS

Stick three or four toothpicks into the sides of an onion, a sweet potato, a carrot top, or a beet top. Immerse the bottom of the specimen in a jar or glass filled with water. Be sure that the specimen does not fall into the water.

RAISING ANIMALS

If you have a pet, observe it daily and keep a record of the food it eats, including its feeding habits. Keep a record of the care you give it. Weigh it once a day at the same hour if a suitable scale is available. Record the weights.

FINDING PROTOZOA AND ALGAE

If you have an aquarium, observe the sides and bottom of the tank every day. Look for a green growth on the sides and for debris on the bottom of the tank. Examine bits of these materials under a microscope or magnifying glass. Look for small living things.

CAUTION: Be sure that the bacteria and yeast cultures are well-covered while being examined. Before transporting them, the cap of each jar should be opened slightly to relieve any pressure, then closed tightly, wrapped securely in many layers of paper, and carried in a box. Upon arrival at school, the cap should be opened slightly and the jar stored in that condition in the science room or laboratory.

Reading Selection

Have pupils read the following selection and answer the questions listed at the end. You may wish to use this selection to stimulate discussion regarding the life of Louis Pasteur.

There is probably no scientist whose discoveries have so changed our way of life as those of Louis Pasteur. When Pasteur was born in 1822, there was no protection against most infectious diseases. Many people died during epidemics. Operations were almost unheard of. When surgeons did operate, incisions usually became infected because no one knew how to protect them against germs. For every two operations carried out, one patient was sure to die.

Now, thanks to Pasteur's work, we can expect to live almost thirty years longer than people did during Pasteur's time. Most operations involve little risk. Many diseases, such as diphtheria, plague, typhoid, and rabies have been almost completely eliminated from many parts of the world. Because of the work of Louis Pasteur, we can live our lives with little fear of the disease and death which was once an everyday threat.

1. Louis Pasteur lived in
   a) 1800 b) 1850 c) 1900 d) 1950

2. Following operations, wounds usually became infected because
   a) there were no hospitals
   b) there were few doctors
   c) there was no protection against germs
   d) x-rays had not been discovered

3. For every two operations done
   a) one patient survived c) four doctors were needed
   b) two patients died d) one was unnecessary

4. We can expect to live longer than people in Pasteur's time about
   a) 10 years b) 20 years c) 30 years d) 40 years

5. A disease that has been completely eliminated in many parts of the world is
   a) the common cold b) influenza c) chicken pox
   d) diphtheria

CELLS

6. WHAT ARE THE BUILDING BLOCKS OF LIVING THINGS?

Outcomes

- The cell is the smallest unit of living things.
- All living things are composed of one or more cells.
- Almost all cells contain a nucleus, cytoplasm, and cell membrane.

Motivation

1. Discuss the work of Robert Hooke.
2. Use the bioscope or microprojector to project a slide of cork on the screen. Point out the holes described by Hooke. He called these "cells" because they reminded him of small rooms (prison cells).

Development

1. Project a previously prepared, stained slide of cheek epithelium, under high power. How do these cells differ from the cork cells? Elicit that there are differences in size, shape, and cellular contents.
2. Project a prepared slide of a cross-section of a leaf. Have pupils point out the various cells that make up the leaf. What similar structures are found in both the leaf cells and the cheek cells? Elicit that each cell has an inner material, an outer boundary that separates it from adjoining cells, and a small, round, darkly stained body in the inner material. For the present, identify these

as cytoplasm, cell membrane, and nucleus. (A later lesson will differentiate between cell membrane and cell wall.)

3. Refer to the lesson dealing with pond water. Elicit that the organisms seen in the pond water were similar in structure to the leaf and cheek cells. Develop the concept that all living things are composed of one or more cells. Identify the cell as the smallest unit of all living things.

4. Have pupils draw a diagram of one of the cells they observed in class, and label the cytoplasm, cell membrane, and nucleus.

5. Exhibit a model of a cell. Elicit that cells are 3 dimensional. Structures such as the nucleus are within this 3 dimensional cell.

6. *Cells are very complex. There are many structures which cannot be seen with the ordinary microscope. Special microscopes, such as the electron microscope, give us a more detailed picture of cells. The teacher may wish to discuss some additional structures found in the cell.*

   a. mitochondria
   b. centrosome
   c. nucleolus
   d. ribosomes
   e. vacuoles
   f. chromosomes

   NOTE: Additional information on cell structure can be found in most high school biology textbooks.

Summary

1. Why are cells called the basic unit of all life?

2. What structures do most cells have in common?

Homework

There are some cells which differ in structure from those mentioned in class. Find out more about one or more of the following cells:

1. Cells without nuclei—red blood cells

2. Cells that have more than one nucleus—striated muscle cells

3. Cells which can be seen with the naked eye—birds' eggs

4. *Parts of living things not made of cells—lens of the eye*

5. *Living things not made of cells—viruses*

Materials

Bioscope or microprojector
Prepared slide of X-section of cork
Prepared slide of cheek epithelium (stained)
Slide of X-section of a leaf (S-1, 12-7918)
Model of cell, amoeba (S-1, 12-3978.01)

7. HOW DO PLANT AND ANIMAL CELLS DIFFER?

LABORATORY LESSON

Outcomes

- There are structures found in plant cells which are not found in animal cells.
- These structures are the cell wall and chloroplasts.
- The centriole is a structure found only in animal cells.

Motivation

Exhibit chart, "Cell Structure—Single Plant and Animal Cells."

Ask, "What are the differences between plant and animal cells?"

Elicit that:

1. The plant cell has a thick wall.
2. The plant cell has small, green bodies within the cytoplasm.
3. The plant cell has a large, clear area within the cytoplasm.
4. The animal cell has a small body near the nucleus.

Identify these as cell wall, chloroplasts, vacuole, and centriole.

Development

1. Distribute Worksheets, microscopes, and prepared slides of plant and animal cells to pupils.
2. Direct pupils to find individual plant and animal cells, using

procedures learned in prior lessons with the microscope and suggested procedures on the Worksheet.

3. Have pupils draw and label diagrams of plant and animal cells.
4. Summarize the lesson, using the questions found at the end of the Worksheet.

Homework

What are some structures found:

1. in both plant and animal cells?
2. in plant cells but not in animal cells?
3. only in animal cells?

Materials

Chart, "Cell Structure—Single Plant and Animal Cells" (S-1, 12-1908)

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—BIOLOGY: LESSON 7

Problem: How do plant and animal cells differ?

Materials

Prepared microscope slides: onion epidermis and amoeba
Lens paper

Procedures and Observations

1. Focus your microscope, following procedures you have learned.
2. Place the slide of the amoeba, which represents a typical animal cell, on your microscope, under low power. Find an individual specimen of an amoeba. Switch to high power.
3. Draw a diagram of an amoeba. Label the parts which you can identify in your specimen.
4. How would you describe the shape of the cell? Where is the nucleus?

5. Place the slide of onion epidermis on your microscope. What type of cell does this represent? Focus under low power and then switch to high power. How many cells can you see?

6. Draw a diagram of an onion epidermis cell. Label those parts which you can identify in your specimen.

ANIMAL CELL (AMOEBA) PLANT CELL (ONION EPIDERMIS)

Conclusion

1. How do animal and plant cells differ in shape?
2. To what do green plants owe their color?
3. How does the size of vacuoles vary in plant and animal cells?
4. *How does the amoeba move?*

8. WHAT DO THE PARTS OF A CELL DO?

Outcomes

- Each part of a cell has a specific job to perform.
- Cells consist of a complex mixture of various chemicals known as protoplasm.

Motivation

Pose the question, "What does the term nucleus mean?" (Refer to previous learnings in Chemistry: Grade 7.) Elicit that nucleus means center (center of an atom).

"Where is the nucleus of a cell? Elicit that the nucleus is not in the center of the cell. "Why, then, is it called the nucleus? What is the nucleus of an airport?" Elicit that the control tower is analogous to the nucleus of a cell. The control tower regulates the activities of the airport, while the nucleus regulates the activities of the cell.

Development

1. Exhibit chart, "Cell Structure—Single Plant and Animal Cells." Have pupils prepare the following chart:

THE CELL		
Structure	Plant/Animal	Function
Nucleus	√ √	Controls activities of the cell. Contains material which determines heredity.

   Use the display cell chart to elicit from pupils other cellular structures previously discussed in class; e.g., cell membrane, cytoplasm, cell wall, vacuole, chloroplast. Have pupils add these to the chart and complete the information.

2. Explain the functions of each of these structures:

   Cell membrane—outer boundary of the cytoplasm. It regulates digested food and oxygen entering the cell and wastes leaving the cell.

   Cytoplasm—all of the inner cellular material, except the nucleus. Various activities and life processes take place here.

   Cell wall—a tough, rigid material which gives plant cells a definite shape. The cell wall is composed of cellulose; i.e., when you eat celery, you bite through cell walls. Wood is composed of cellulose cell walls.

   Vacuole—cellular bubbles or spaces containing sap-like liquids in plants. These vacuoles are storage places inside the cells. Some animal cells may contain vacuoles also.

   Chloroplast—small green bodies which contain chlorophyll in the cytoplasm of plant cells. Green plants need chlorophyll to make food.

3. Point out that all of this living material, inside the cell, is known as *protoplasm*.

4. Genes *form chromosomes in the nucleus and determine heredity traits by means of a remarkable substance called DNA (deoxyribonucleic acid).*

Large granules in the cytoplasm called MITOCHONDRIA *release energy as needed by the cell through a chemical called ATP (adenosine triphosphate).*

Smaller granules in the cytoplasm known as MICROSOMES *direct the manufacture of proteins for growth and repair by means of a compound called RNA (ribonucleic acid).*

Summary

1. Why are plants usually more rigid in structure than animals?
2. Which structure regulates the entrance of food and oxygen into the cell?
3. What gives green plants their color?

Homework

Construct a gelatin model of a cell. Use items in your home for the different structures studied in class; e.g., a grape for the nucleus. Models may also be constructed from clay or construction paper.

Materials

Chart "Cell Structure—Single Plant and Animal Cells" (S-1, 12-1908)

9. WHY DO CELLS HAVE DIFFERENT SHAPES?

Outcomes

- Cells vary in size and shape.
- Cells are specialized to perform specific jobs.
- The shape of a cell is related to the job it performs.

Motivation

Pose the question, "Are all cells the same size?" Show a microprojection of epithelial cells from the cheek. Ask the class to describe the size of these cells. Elicit that they are too small to be seen with the naked eye.

Open an egg into a petri dish or beaker and circulate the yolk for the pupils to see. Identify this as *one* cell. Ask pupils why the yolk or egg cell is so large. Elicit that the yolk contains stored food for the growing chick to live on while it is confined in the shell.

Development

Exhibit chart, "Types of Cells" or models, "Cells of Human Tissues."

Identify each type of cell and its function and have pupils discuss how the shape of each cell is related to the function of the cell.

CELL	FUNCTION
Epithelial	Covers surface of the body, inside surface of digestive tract, inside of the nose, throat, and windpipe. Protects the body and produces secretions.
Nerve	Carries impulses which cause muscles to act and tells us about our surroundings. Some nerve cells are several feet long.
Muscle	Produces movement through contraction and relaxation.
Blood Red cell	Carries oxygen (O_2) to body cells and carbon dioxide (CO_2) to lungs.
White cell	Engulfs and destroys germs.
Bone	Makes up the body framework and aids in body movement.
Root hair	Absorbs water and minerals from the soil.
Guard cell	Regulates amount of O_2 and water leaving the leaf and amount of CO_2 entering.
Egg and sperm	Form new living things.

Discuss the motility of certain cells (white blood cells and sperm cells) as an aid in performing their specific functions. The sperm cell must be able to move to reach the egg cell. White blood cells move in a manner similar to an amoeba. They are able to move through the walls of capillaries to diseased cells in order to attack bacteria which enter the body.

Summary

1. What are the longest cells in our body?
2. What types of cells is blood composed of?
3. How does the shape of muscle cells aid them in performing their function?

Homework

1. How are nerve cells like telephone wires?
2. Which cells perform the function of transport in the body?
3. *Explain how white blood cells destroy bacteria.*

Materials

Microprojector
Prepared slide of cheek cells
Egg
Petri dish or beaker
Chart: Types of Cells (S-1, 12-2278)
Models: Cells of Human Tissues (S-1, 12-3868)

10. HOW DO CELLS WORK TOGETHER IN LIVING THINGS?

Outcomes

- A group of cells, similar in structure and function, which work together, is called a tissue.
- A tissue is named for the work it does or for its location.

Motivation

Review the types of cells studied in the previous lesson. Display a chart of different types of cells (S-1, 12-1918), and call on pupils to identify each type of cell and relate its function. Elicit that large numbers of each type of cell are usually found working together.

Development

1. Identify these groups of similar cells, working together, as tissue.

2. Emphasize the role of the tissue as opposed to the role of the single cell. As an example, relate the function of a tissue to the use of the protective plastics as covers for food.

3. Show prepared slides or transparencies of some of the tissues listed. Have pupils identify each by the cells it contains and relate its function to the function of its cells.

TISSUE	FUNCTION
Epithelial	Provides protection
Nerve	Carries messages
Bone (connective)	Composes framework and allows for movement
Muscle	Produces movement
Blood	System for transport and protection

4. *Bone tissue is only one of several different types of connective tissue. Duplicate and distribute a list of tissues to the class. Have pupils determine the occurrence of each by its function.*

CONNECTIVE TISSUE	FUNCTION
Bone	Composes framework and allows for movement
Cartilage	Acts as cushion, gives rigidity to structures without bones, provides slippery surface for joints
Dense fibrous	Joins muscles to bones or bones to bones to aid movement, carries the blood supply
Loose fibrous	Holds organs together, acts as a filler, cushions and insulates, stores fat

5. *Are all muscle tissues the same?*

There are 3 types of muscle tissue

MUSCLE TISSUE	LOCATION
Smooth	In internal organs
Skeletal	Attached to skeleton
Cardiac	In heart

How is cardiac muscle different in appearance from skeletal muscle? Also, elicit that we cannot control cardiac muscle while we can control skeletal muscle.

Summary

1. What is the difference between a cell and a tissue?
2. What type of cell makes up blood tissue?

Homework

1. What types of tissues make up your hand?
2. *List the types of tissues which compose each of the following structures: outer ear, heart, inside of mouth.*

Materials

Chart of cells (S-1, 12-1918)

Microprojector or microscope

Prepared slides or transparencies of animal tissues

11. HOW DO TISSUES WORK TOGETHER TO FORM ORGANS?

Outcomes

- Many different tissues work together to form an organ.
- Each body organ has a specific job to perform.

Motivation

Demonstrate the coordinated functioning of different tissues in a dissected chicken leg. Prepare the chicken leg, prior to the lesson, in the following manner: Remove the skin from the complete leg and separate the individual muscles and tendons to the toes by carefully cutting the connective tissue between them. Show that the contraction of individual muscles moves specific toes by means of tendon connections to the bones. Identify the nerve as the tough, white cor which stimulates muscle contraction. Identify the chicken leg as a *organ.*

Development

1. Explain that movement occurs through the coordinated action o many tissues: muscle, connective, nerve, and bone. Elicit that a organ is a group of tissues working together to perform a specifi function.

2. Ask pupils to name several other body organs and list these on th board. Next to each organ, have pupils list the tissues each orga is composed of and the function of the organ. Example: (Hav pupils complete chart at home.)

ORGAN	TISSUE TYPE	FUNCTION
Hand	Epithelial, connective, muscle, blood, nerve, etc.	Picking up objects Helping us learn through touch
Heart	Cardiac muscle, blood	Pumping blood through body

3. Exhibit a model of a human torso. Remove various parts of th torso and have pupils identify them. Elicit that each is an orga Through further class discussion, elicit that: Organs are varied i shape and location. To function properly, each organ makes use o many different tissues.

4. Do plants also have organs?

   In plants, as in animals, groups of cells work together to for tissues, and various tissues work together to form organs.

   Exhibit a plant stem. Identify this as an organ. Ask pupils to poi out various tissues composing the stem. Identify these tissues a bark, wood, and pith. What is the function of the stem? Elicit tha the stem supports the leaves, flowers, and fruit and conducts ma terial through the roots and the leaves.

5. *What are some other plant organs? Exhibit a plant and ask pupi to point out other organs. (Those organs you might wish identifie are the stem, roots, leaves, and flowers. The flower itself is co posed of several different organs.)*

What are the functions of each of these organs?

Organ	Function
Stem	Support, conduction
Roots	Absorption of water and minerals
Leaves	Production of food (*future lesson*)
Flowers	Reproduction

Summary

. What is the difference between a tissue and an organ?

. What types of tissues must work together for you to move your finger?

Homework

. Name the 5 sense organs.

. Why are the sense organs well supplied with nervous tissue?

. *The flower has reproductive organs. What are the names of these organs? (Refer pupils to specific books for this information.)*

Materials

Chicken leg	Portion of plant stem
Model of human torso (S-1, 12-3838)	*Plant (geranium)*

2. HOW DO ORGAN SYSTEMS CONTROL OUR ACTIVITIES?

Outcomes

A group of organs which work together to perform a specific job is called an organ system.

Our organ systems work without our conscious effort.

Motivation

Exhibit a model or chart of the human digestive system. Ask pupil the function of some organs. Elicit that all of the organs play a role i digestion. Have pupils come to the chart and trace the path of particle of food through the digestive organs. Elicit that all digestiv organs are connected and are identified as the *digestive system.*

Development

1. Exhibit a chart of the circulatory system. Why is this called th circulatory system? Elicit that all organs in the system are involve with the circulation of blood. Identify some of these organs (hear arteries, veins). Elicit that a group of organs which work togethe to perform a specific function is called an *organ system.*

2. Make a list of body systems on the chalkboard. Ask pupils to explain the function of each system and to describe *some* of th organs which compose each system.

SYSTEM	FUNCTION	ORGANS
Digestive	Digestion of food	Stomach, intestines, liver, etc.
Circulatory	Circulation of blood	Heart, veins, arteries
Excretory	Excretion of wastes	Kidneys, bladder
Respiratory	Respiration: taking in oxygen and eliminating carbon dioxide	Lungs, windpipe
Nervous	Transmission and reception of messages which tell us about our surroundings or tell our body to act.	Brain, nerves

Point out that the names of the systems tell us what they do.

3. Pose the question, "What is the relationship between cells, tissue organs, and organ systems?" Demonstrate this relationship:

   cell → tissue → organ → organ system → organism

   What is an organism? Elicit that organisms are living individual

   NOTE: There are also one-celled organisms which are not compos of complex organ systems.

4. *Group pupils in pairs. Instruct them how to take pulse and respiration rates. Have one pupil take his partner's pulse and respiration rate, while the latter is relaxed, and record this information. Next have the same pupil record his partner's pulse and respiration after his partner had jumped up and down 25 times.*

   Elicit that activity increases pulse and respiration rate. Now ask pupils to consciously increase their pulse and respiration rates. Point out that our organ systems work without a conscious effort.

Summary

1. What is an organ system?
2. What is the function of the respiratory system?
3. Why is the cell called the basic unit of all living things?

Homework

1. Why are we called organisms?
2. Explain why each organ system is composed of many types of cells.

Materials

Model of digestive system (S-1, 12-3728) or Chart (S-1, 12-3138)
Chart of circulatory system (S-1, 12-3148)

13. WHAT CAN WE LEARN ABOUT THE ORGAN SYSTEMS OF FISH?

LABORATORY LESSON

Outcomes

- The organ systems work together in an organism.
- The organ systems of fish are quite similar to those of man.

Motivation

Exhibit several goldfish in a bowl. Pose the question, "How do fish breathe?" Elicit that breathing is related to the movements of the mouth and gill covers.

Development

1. (Obtain a medium-sized fish from a meat or fish market. The fish can be preserved in 8% formalin or formaldehyde solution.) Exhibit the fish to the class. Place a wood splint or a glass rod under the gill cover and push it out through the mouth. Relate this to the movements of the mouth and gill covers previously observed. Lift and remove gill cover to show the structure of the gills. Elicit that oxygen is removed from the water as it passes over the gills.
2. Distribute Worksheets and materials to pupils.
3. Exhibit chart or model of the perch. Point out the location of the various organ systems. Have the pupils dissect the fish according to Worksheet instructions.
4. Summarize, using the questions at the end of the Worksheet.

Homework

1. How is the respiratory system of a fish different from that of a man?
2. What happens to a fish when its gill covers are held closed? Why?

Materials

Bowl of goldfish
Medium-sized, preserved fish
Wood splint or glass rod

Chart of perch (S-1, 12-2778) or
Model of perch (S-1, 12-3958)

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—BIOLOGY: LESSON 13

Problem: What can we find out about the organ systems of fish?

Materials

Fish (mackerel, perch, smelt, porgy, whiting)
Dissecting tray
Scalpel
Probe
Scissors
Hand lens

Procedure and Observations

1. Look at the fish carefully:

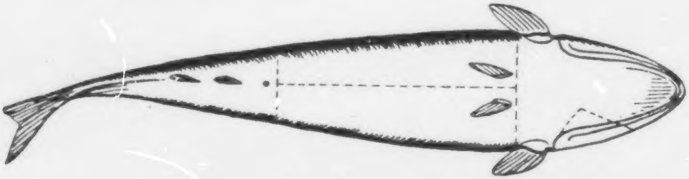
   a. What kind of outside covering does the fish have? ____________________

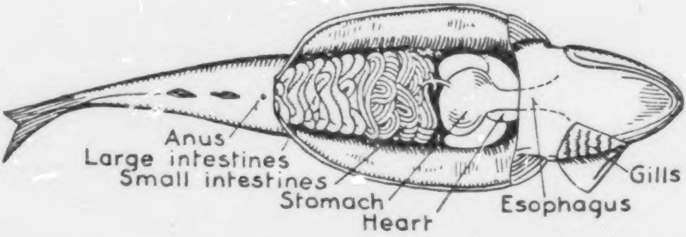
   b. How does it feel? ____________________

   c. How many fins does the fish have? ____________________
   By their appearance and position, what special job might each of the fins have? ____________________

2. Turn the fish on its side. Cut away the gill cover on one side as your teacher did. What does the gill system look like? Draw a simple diagram.

3. Using a scalpel, make two cuts across the fish as shown in the diagram. Using scissors, cut down the middle of the "stomach" between the first 2 cuts. Fold back the skin and muscles so that you can see the organs inside.





4. What organs can you see?

   a. Locate these organs:
   Esophagus
   Stomach
   Large intestine
   Anal opening
   Small intestine
   Liver, gall bladder

   b. Using a probe, lift all the parts and list other parts you can see. Compare the parts you see to those on the chart or model of the fish.

   c. What circulatory organs can you identify?

Conclusions

1. In what ways are the systems of man and fish similar?
2. What differences do you observe?
3. What is a system?

REINFORCEMENT AND REVIEW (6—13)

NOTE: The instructor may select the most suitable of the following suggestions for review and reinforcement.

Audio-Visual Aids

FILMSTRIPS

Plant Cells (AV List 38680.16) History of cell study, main parts, and their functions, types of specialized cells.

Introducing Cells (38430.16) Study of simple plant and animal cells: characteristics, needs, and functions.

What Is a Cell? (40314.2) Cells, parts, and functions; different types of body cells.

FILMS (16 mm)

Simple Plants: Bacteria (BAVI) Shows the major charcteristics of the 3 known groups of bacteria.

World of Micro-life (BAVI) Shows structure and reproduction in microorganisms, including bread mold.

Amoeba (BAVI) Microphotography and animated drawings show the structure and life functions of a single-celled organism.

Tissues of the Human Body (BAVI) Details the organization of the basic kinds of tissues.

Tissues of the Human Body (AV List 605.51) Compares the life processes of the one-cell organism with the human.

Observation

Pupils can investigate the world of tiny things through a magnifying lens or microscope.

1. They can see the sparkle and beautiful symmetry of crystals of salt or sugar.
2. They can examine the structure of insects.
3. With the aid of a microscope, the cells of plants, as well as the delicate network of veins in leaves, can be observed.
4. Newspaper and magazine pictures become a series of colored dots under a magnifying lens.
5. The skin is observed to be like a moonlike expanse of craters and ridges.

Research Topics

1. *ATP—Adenosine Triphosphate: Energy Mechanism of the Cell*
2. The Role of the Centriole in Cell Reproduction
3. *DNA—Deoxyribonucleic Acid: Master Molecule in the Cell*
4. *DNA—and Heredity*
5. The Golgi Complex in the Cell
6. The Mitochondrion: Storehouse of Energy for the Cell
7. *Conduction of Nerve Impulses by Nerve Cells*
8. The Endoplasmic Reticulum
9. Cellulose: Building Matter of Plant Cell Walls

NUTRITION

14. WHAT USEFUL CHEMICAL SUBSTANCES DO FOODS CONTAIN?

Outcomes

- All foods contain useful substances called nutrients. The nutrients required by all living things include: sugar, starch, fats, proteins, vitamins, minerals, and water.
- Nutrients supply the body with energy and aid in the growth and repair of tissue.

Motivation

Ask pupils to describe the foods eaten by household pets or by familiar zoo animals. List these on the chalkboard. Elicit that food is a basic need of living things.

Development

1. Pose the question, "Why do we eat food?" Elicit that food is necessary for the growth and repair of tissue and is a source of energy for the body.
2. What types of food are good sources of energy? Ask pupils which television advertisements (commercials) identify food products as being sources of energy. List these on the board.

   Point out that each of these foods contains certain chemicals in common. Identify these chemicals as *sugar* and *starch*. You may wish to identify these as *carbohydrates*.

3. Which food products are advertised as containing substances needed for growth and repair? List these on the board. Identify the chemical common to these foods as *protein*.

4. Exhibit an empty milk container to the class. What is added to the milk to enrich it? Point out that the Vitamin D in milk is but one of a group of other important chemicals called vitamins.

5. Identify the useful substances found in food as nutrients. Place the list of nutrients on the board:

   Sugar Starch Protein Vitamins Minerals Fats & oils Water.

6. Exhibit a food chart showing nutritive values of common foods. Pose these questions:

   What foods are good sources of starch?

   Which foods are rich in sugar?

   What protein-rich foods come from plants? animals?

   If a doctor recommends that fats be eliminated from the diet, which foods should not be eaten?

   Why is milk called the "perfect food"?

   Which foods are poor sources of nutrients?

7. *What is the material of all living cells called?*

   Protoplasm is a complex mixture of many chemicals. The symbols of the most important elements making up the chemicals in protoplasm are: C, O, H, N, S, P, Fe, Ca, K

   Give full name of each element represented here. Where does the body obtain these elements? Elicit that the foods we eat are sources of these elements.

Summary

1. What is meant by a nutritious (nutrient) food?

2. Why do athletes eat foods containing sugar, prior to competing in athletic contests?

3. Why is it important for children to include many protein-rich foods in their diet?

Homework

1. Prepare a 3-day diet which will supply you with all the nutrients necessary to stay healthy.
2. Obtain several food containers and copy the nutrient content from the labels.

Materials

Empty milk container Food chart

15. WHAT IS A FOOD TEST?

Outcomes

- Some chemicals change color when they are added to particul nutrients. These chemicals can be used to indicate which nutrien a food contains.
- When a chemical changes color with only one nutrient, it can be used in a food test.
- Iodine turns black when it is added to starch.

Motivation

Tell pupils that doctors advise people who are overweight to eliminate starch from their diet. Ask pupils to select some foods containing starch which they would not include in the diet. List these on the board. Ask, "How can we be sure that these foods contain starch?"

Development

1. Exhibit a set of seven labeled test tubes, each one-third full of a nutrient listed under Materials.

   Which nutrient does each of these represent?

   On the chalkboard, list each of the samples and the nutrient represented.

2. Add several drops of Lugol's solution to each test tube. Call upon pupils to observe the reactions, if any. List the observation on the

board. Elicit that the color changed to blue-black only in the test tube containing the starch suspension. Identify Lugol's solution as one containing iodine.

3. Discuss the implications of this demonstration. Elicit that the color reaction forms the basis for the chemical test *for starch only*.

   Why did we add Lugol's solution to *all* of the nutrients? Elicit that the tests made with the other nutrients were for comparison purposes and are called *controls*.

4. Guide pupils to identify an important criterion for a successful *food test*. Elicit that one criterion of a successful test involves a color change that is specific for each nutrient.

5. Exhibit several food samples to the class. Have pupils test these to find examples of foods which contain starch. Some food samples:

   Bread
   Potato
   Lettuce
   Carrot
   Meat
   Cooked egg white
   Cooked spaghetti or macaroni

Summary

1. How can we find out if a food contains starch?
2. How can we tell which nutrients a food contains?
3. Why is it important that the Lugol's solution react only with the starch suspension?

Homework

Use iodine to test foods at home for starch content. List tested foods which contain starch and those which do not contain starch.

Materials

Seven labeled test tubes in a rack, each one-third full of one of these nutrients:

Starch suspension
2% glucose or dextrose solution
2% peptone or beef broth suspension
2% table salt solution (Vitamin C)
½ ascorbic acid tablet (Vitamin C) dissolved in water
Water
Corn or olive oil
Lugol's solution

(*Continued*)

Food samples:
- Bread
- Potato
- Lettuce
- Carrot
- Meat
- Cooked egg white
- Cooked spaghetti or macaroni

16. HOW CAN WE FIND OUT IF FOODS CONTAIN SUGAR?

Outcomes

- Benedict's solution can be used to test foods for sugar.
- When Benedict's solution is added to a simple sugar and heated, the mixture will change color from blue to green, to yellow, to orange, and finally to red.

Motivation

Review the criteria for a successful food test.

Present the following problem to the class: Diabetics must restrict their intake of sugar. How can we find out which foods contain sugar? Elicit that we have to find a substance which changes color only when mixed with sugar. Exhibit a bottle of Benedict's solution and identify it as a chemical which can be used to test for sugar.

Development

1. Prepare a set of seven test tubes, each one-third full of a different nutrient. (See materials at end of lesson.) Add one-third of a test tube of Benedict's solution to each of these tubes. Ask pupils to identify any reaction that has occurred. Explain to the class that in order to get a reaction the solution must be heated.
2. Gently heat each test tube in turn. Have pupils describe the reaction between Benedict's solution and sugar. Elicit that the mixture of Benedict's solution and sugar, when heated, changes color from blue, to green, to yellow, to orange, and finally to red.
3. Show the applicability of this test by testing several foods with

Benedict's. Foods which may be used are milk, bread, onion, egg white, candy, a piece of apple or other fruit. On the chalkboard, list foods that contain sugar and foods that do not contain sugar.
NOTE: Sucrose or table sugar will not react with Benedict's solution since it is not a simple sugar.

4. *Fill a test tube one-third full of a 2% solution of sucrose or table sugar. Add one-third of a test tube of Benedict's solution and heat. Ask pupils why there is no reaction. Elicit that table sugar is chemically different from glucose or dextrose. Identify glucose and dextrose as simple sugars and sucrose as a complex sugar. Benedict's solution will react only with simple or reducing sugars.*

Summary

1. How does Benedict's solution react with simple sugar?
2. What is the test for sugar? starch?

Homework

1. Describe the test for sugar.
2. Describe the test for starch.

Materials

Benedict's solution
Bunsen burner
Test tube holder
Onion
Piece of fruit
Milk
Bread
Egg white
Candy
Rack with 7 test tubes, each ⅓ filled with one of:
  Starch suspension
  Corn or olive oil
  Water
  2% table salt solution
  2% glucose or dextrose solution
  2% peptone or beef broth suspension
  Part of ascorbic acid tablet dissolved in water

17. WHAT ARE THE TESTS FOR THE OTHER NUTRIENTS?

Outcomes

- Biuret solution turns pink or violet when it is mixed with proteins.
- Indophenol, a blue chemical, becomes clear when Vitamin C is added to it.
- A completely burned food leaves an ash which is its mineral content.
- When fat is rubbed on brown paper, a spot appears on the paper. Light can pass through this spot (it is translucent). Heating does not remove the spot.
- Heating food causes water in the food to form vapor which can be collected by cooling.

Motivation

Exhibit a sample of apparently dry food, such as a piece of toasted bread or a raisin. Heat the sample in a test tube. Have pupils identify the droplets on the cooler, upper inside of the tube, as water. Elicit that food can be tested for water content by heating. Heating causes the water in the food to evaporate. The water can then be collected by cooling the vapor.

Development

1. Heat a sample of food, such as a piece of bread, in a crucible or evaporating dish, until only ash remains.

   NOTE: Since this will take several minutes, it will be well to go on to the next demonstration.

   What remains after heating? Elicit from pupils that the unburned charred ash which remains represents the mineral content in the food.

2. To one-third of a test tube of water, add a small amount of raw egg white or powdered albumin. (Identify these as protein-rich materials.) To this mixture, add one-third of a test tube of Biuret solution. Have pupils compare the color of the new mixture with the original color of the Biuret solution. Elicit that Biuret solution turns violet or pink in the presence of protein.

3. *Place several pieces of boiled egg white in a pyrex test tube and cover them with concentrated nitric acid.*

   CAUTION: This step should be done with extreme care. Nitric acid is very caustic.

   Using a test tube holder, gently heat the test tube with boiled egg white and nitric acid, holding the mouth of the test tube away from the face.

   Heat the mixture to boiling and then pour off the acid. Rinse the egg white with water. Add some dilute ammonium hydroxide to the test tube. Elicit that the orange color deepens with the addition of the hydroxide, which indicates the presence of protein. Why is this test useless with sources of protein, such as milk and cheese?

4. Place one inch of indophenol solution in a test tube. Using a medicine dropper, add, drop-by-drop, a solution of 1% ascorbic acid (Vitamin C). Shake well with each drop. Have pupils observe the change from blue to a colorless state.

   NOTE: The intermediate pink should be disregarded.

   Elicit that indophenol becomes clear when Vitamin C is added to it. Explain that indophenol solution can *only* be used to test for Vitamin C, which is but one of many vitamins.

5. Rub some butter or oil on a piece of unglazed paper. Treat a second piece of paper in a similar way, using water instead of oil. Have pupils observe the translucent spot which appears on both pieces of paper. Heat both pieces of paper over a hot plate, lamp, or radiator. What happens to the paper treated with water? Elicit that the heat causes the water to evaporate and the water spot disappears. The translucent fat spot remains.

Summary

1. Which food tests involve the change in color of specific chemicals?
2. Why is it difficult to test a single, small food sample for all the nutrients?

Homework

1. For the next lesson it will be necessary to bring in samples of various foods. (The teacher may make suggestions as to kinds.)

2. Make a chart completing the information asked for in the three columns:

NUTRIENT	FOOD TEST	COLOR CHANGE (IF ANY)

Materials

Piece of toast	Indophenol solution
Raisin	Crucible or evaporating dish
Oil or butter	1% ascorbic acid solution
Hot plate	Raw egg white or powdered albumin
Ring stand	2 pieces unglazed paper
Wire gauze	*Test tube*
3 test tubes	*Cooked egg white*
Test tube holder	*Concentrate nitric acid*
Biuret solution	*Dilute ammonium hydroxide*
Medicine dropper	

18. WHAT NUTRIENTS CAN WE FIND IN COMMON FOODS?

LABORATORY LESSON

Outcomes

- Food samples can be tested for the presence of each of the nutrients, using specific food tests.
- Foods usually contain several different nutrients.

Motivation

Have pupils exhibit several of the food samples brought from home. Ask pupils to make tentative suggestions about the nutrient content of these foods. List these foods and their tentative content on the board.

Development

1. Briefly review and note the following food tests on the chalkboard:

Test for *starch:*	Lugol's solution turns black or blue.
sugar:	Benedict's solution turns green, yellow, orange, or red when heated.
protein:	Biuret solution turns violet or pink.
fats and oils:	When rubbed on unglazed paper, fats and oils produce a translucent spot which does not disappear when heated gently.

NOTE: Tests for Vitamin C, minerals, and water will not be conducted during this laboratory lesson.

2. Distribute Worksheets and materials to pupils. Pupils should work in groups of four, so that each pupil will be able to conduct a different test. Each group divides the responsibilities for the tests.

3. Have each group of pupils divide each food sample into four parts. Explain that each food is to be tested for four nutrients.

4. Summarize by using the questions at the end of the Worksheet.

Homework

1. Which food that you brought from home do you consider to be the most nutritious? Why?

2. Test several foods at home for fat and oil content. Make a chart using your results.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—BIOLOGY: LESSON 18

Problem: What nutrients can we find in common foods?

Materials

Food samples from home
Benedict's solution
Lugol's solution
Biuret solution
6 pieces unglazed paper
4 racks, 6 test tubes in each
Alcohol lamp
Test tube holder

Procedures and Observations

1. Divide responsibilities so that each pupil will conduct one of the tests on all of the samples.
2. Divide each food sample into 4 parts. Place one part of each sample into one test tube in each rack and label the tube.
3. Find out what nutrients are present in each of your food samples. Write your results on the Table of Observations. Indicate the presence of a nutrient with the word *present* and its absence with the word *absent*. Leave the space blank when you may not be able to test for a specific nutrient.

TABLE OF OBSERVATIONS

FOOD	STARCH	SUGAR	PROTEIN	FATS AND OILS
1.				
2.				
3.				
4.				

Conclusion

1. Which of your results surprised you? Why?
2. Which foods contained all four nutrients?
3. Which foods contained only one nutrient?
4. Did you find that most foods contained one or several nutrients?
5. Did your results differ from those of other pupils? If so, why?
6. *Are the tests you made sufficient for a final judgment about what the foods contain? Explain.*

19. HOW DO LIVING THINGS OBTAIN ENERGY?

Outcomes

- Foods provide living things with energy.

- Oxidation of foods in our body produces heat energy, carbon dioxide, and water.
- Carbohydrates and fats are the chief sources of energy.
- *We can measure the energy content of foods. The energy unit in foods is called the Calorie.*

Motivation

How do athletes get quick energy prior to or during an athletic contest? Elicit that athletes usually eat foods containing sugar for energy.

Development

1. Exhibit a marshmallow. Identify the marshmallow as a source of sugar. Pose the question, "How can we show the energy in a food?" Hold a marshmallow with a pair of tongs over a flame until it ignites. Ask pupils what forms of energy are released by the marshmallow. Elicit that heat and light energy are given off. What kind of a chemical reaction is this? (Refer pupils to learnings in Grade 7: Chemistry.) Elicit that the marshmallow is being oxidized and the reaction is exothermic.
2. Point out the blackened exterior of the marshmallow. Have pupils identify this substance as carbon. Elicit that the marshmallow must consist of carbon compounds.
3. What other elements can we find in the marshmallow? Ignite a second marshmallow. Run the flame from the burning marshmallow over the chalkboard. Have pupils identify the damp area on the board as consisting of water. "Where did the water come from?" What elements is water composed of? Elicit that the marshmallow must also contain hydrogen and oxygen.
4. Invert a wide-mouthed collecting bottle over the flame from the marshmallow. Pour some limewater into the bottle, stopper, and shake till the limewater turns cloudy. Elicit that another product of the burning of the marshmallow is carbon dioxide. As a control, repeat this, using a second bottle and an unburned marshmallow.
5. What elements is the marshmallow composed of? Elicit that the marshmallow contains carbon, hydrogen, and oxygen. What are the products of oxidation of the marshmallow? Write the following

formula on the board. (It will not be necessary to write this as a balanced equation.)

$$\underset{\textit{Sugar}}{C_6H_{12}O_6} + \underset{\textit{Oxygen}}{O_2} \rightarrow \underset{\textit{Heat and light}}{\text{Energy}} + \underset{\textit{Carbon dioxide}}{CO_2} + \underset{\textit{Water}}{H_2O}$$

6. Does oxidation take place in living things?

   Have a pupil exhale on the chalkboard. Elicit that the air we exhale contains water vapor. Have a second pupil exhale into a bottle containing limewater. Why does the limewater turn milky white? Elicit that the air we exhale also contains carbon dioxide.

   Discuss the fact that many living things are warmer than their surroundings. Where is this energy produced? Elicit that living things require food and oxygen. Oxidation of food will release heat energy as well as CO_2 and H_2O.

7. Introduce the concept that nutrients can be oxidized. Burn a peanut.

   Burn a peanut or a butter candle and a cube of sugar dipped in cigarette ash. Identify those foods, which are used as sources of energy by the body, as sugars, starches, and fats. (Protein is also an energy source, but it is not as good a source as the others.)

8. *How can we find out how much energy food contains?*
   NOTE: In Grade 7: Physics, pupils learned how to measure heat energy by heating water in a calorimeter.

   Ignite a peanut and use the flame to heat a test tube of water. Measure the temperature rise in the water. Heat a second test tube of water with the flame of a burning cube of sugar. Measure the rise in the water. Elicit that the rise in temperature is related to the energy content of the food. Identify the energy unit in foods as the Calorie.

Summary

1. How do living things obtain energy to carry out their life processes?
2. How is this energy obtained?
3. What are the products of oxidation of foods?
4. What nutrients are the best sources of energy?

Homework

1. Why are the energy requirements of teenagers greater than those of adults?
2. Why is our body temperature greater than the temperature of our surroundings?
3. What nutrients are the best sources of energy?
4. What is the difference between a Calorie and a calorie?

Materials

4 marshmallows
3 wide-mouthed bottles
Limewater
Peanut or butter candle
Peanut
Sugar cube and cigarette ashes
Thermometer
2 test tubes of water
Test tube holder

20. HOW DO PLANTS OBTAIN THEIR ENERGY?

Outcomes

- Green plants synthesize the nutrients they need to carry on life activities by the process called photosynthesis.
- In the presence of sunlight, green plants utilize the green pigment chlorophyll to produce sugar and starch and release oxygen as a waste product. The raw materials needed for this process are carbon dioxide and water.
- *Animals are dependent on green plants.*

Motivation

NOTE: Several days prior to this lesson, cover two or three of the leaves of a variegated geranium plant with black construction paper or aluminum foil, as shown in this diagram. Place the plant in sunlight until it is ready for use.

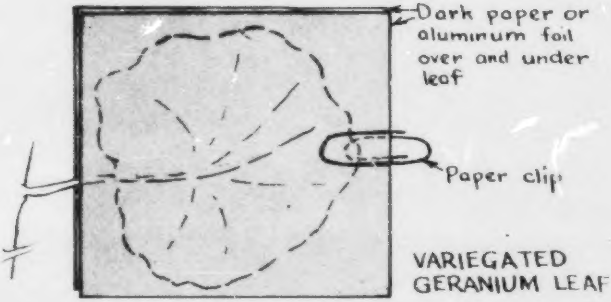


Exhibit the geranium plant to the class. Ask pupils to list on the board some of the life activities of the plant. Pose the question, "How do plants obtain nutrients to supply energy to carry out these life activities?" Point out that plants do not take in nutrients (starches, sugars, proteins, etc.) as animals do. Why then, do we find these nutrients in the plants?

Development

1. Explain that the geranium plant has been exposed to sunlight for several days. Remove one of the covered leaves and exhibit it to the class. Remove the covering and cut a notch in its side to identify it later. Remove an uncovered leaf. Compare the two leaves. What effect has the aluminum foil or construction paper had on the covered leaf? Elicit that it has not received any sunlight.

   Point out the white edge of the variegated geranium leaf. Elicit that the lack of green pigment indicates an absence of chlorophyll.

2. Boil both leaves in alcohol, over a hot plate, until they are blanched. If a hot plate is not available, place both leaves in a small beaker of alcohol and heat the beaker in a water bath or pan of water. CAUTION: The alcohol vapors are extremely flammable.

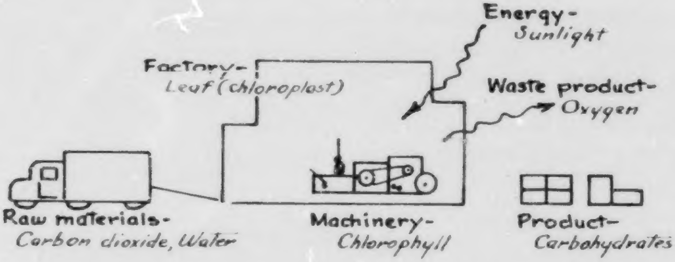
   When the chlorophyll has been removed from the leaves, rinse them and spread them on the bottom of a petri dish. Cover the leaves with Lugol's solution. When there is no more darkening of the leaves, rinse off the iodine solution and exhibit them against a white background.

   Elicit that the cholorophyll-bearing portion of the uncovered leaf shows the presence of the nutrient starch.

Where did the starch come from? Elicit that the starch must have been produced by the plant. What did the experiment show us that is needed for plants to produce starch? Elicit that chlorophyll and sunlight are necessary for starch production. Identify this process as *photosynthesis*.

3. What raw materials are needed for photosynthesis? Have pupils recall experiences in growing plants. Plants need water, which is absorbed from the soil by the roots of the plants. Plants need air. Identify the gas present in air, which is needed in photosynthesis, as carbon dioxide. (Plants also use oxygen, but not as part of the process of photosynthesis.)

4. Why are green plants called "food factories"? Use the following diagram to develop an analogy between a leaf and a factory.

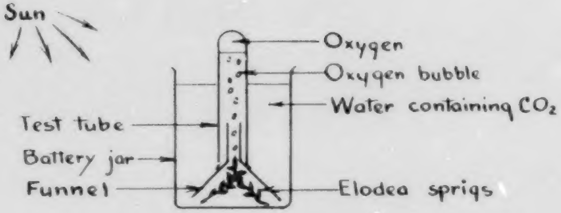


5. *Why are animals dependent on green plants? Fill a 6" or 8" battery jar with tap water. Saturate the water with carbon dioxide by blowing into it with a straw.*

Fill the body of a 4" funnel loosely with actively growing sprigs of Elodea. Invert the funnel in the water with the rim supported on a few pieces of glass tubing to hold it off the bottom. The stem of the funnel should be under water.

Fill a test tube with water, inverting it in the battery jar while it is still full. Slip it over the stem of the funnel and set the entire apparatus in bright sunlight for 24 hours.

Remove the test tube, keeping a thumb over the open end, and test for oxygen with a glowing splint. Elicit that oxygen released by green plants during photosynthesis is necessary for respiration in animals. Why are green plants and animals both necessary in a balanced aquarium?


Sun
Oxygen
Oxygen bubble
Water containing CO2
Test tube
Battery jar
Funnel
Elodea sprigs

Summary

1. What are the raw materials needed for photosynthesis?
2. Why is it that only green plants can carry on photosynthesis?
3. Why is sunlight the source of energy for all living things?

Homework

1. Why are green plants important to all living things?
2. Why is it said that all food comes from green plants?
3. Explain the process of photosynthesis.

Materials

Variegated geranium plant	*6″ or 8″ battery jar*
Paper clips	*Straw*
Aluminum foil or dark construction paper	*4″ funnel*
Beaker	*Sprigs of Elodea*
Hot plate, water bath, or pan	*Pieces of glass tubing*
Petri dish	*Test tube*
Lugol's solution	*Wood splint*

21. WHY ARE PROTEINS IMPORTANT FOR US?

Outcomes

- Proteins supply the body with materials for growth and repair of tissue.

- Protein is necessary for the formation of new protoplasm.

Motivation

Have pupils recall that foods supply living things with energy and raw materials for growth and repair. Elicit that carbohydrates and fats are sources of energy. Pose the question, "Which nutrients aid in growth and repair of tissues?"

Development

1. Protoplasm, living tissue, is a complex mixture of compounds composed mainly of carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorus. Elicit that carbohydrates and fats can supply the body with carbon, hydrogen, and oxygen, but to build new protoplasm we must also have nitrogen, sulfur, and phosphorus.
2. Heat a sample of meat. Identify this as a source of protein. Demonstrate, through the charring, that it contains carbon. Collect the vapor driven off on a cool glass plate. Have pupils identify this as water. List these elements, present in protein, on the chalkboard.
3. Through the conspicuous odor, different from that of burning carbohydrates, elicit that other elements must also be present. Identify these as nitrogen, sulfur, and phosphorus, and list them on the board also. Why are proteins necessary to build new protoplasm? Elicit that only proteins can supply the body with certain needed elements to build new protoplasm.
4. What foods are good sources of protein? Have pupils recall commercials or ads that promote foods important for growing children. List these protein-rich foods on the board:

   meat fish poultry and eggs dairy products
5. *Proteins are large molecules composed of chains of smaller molecules called* AMINO ACIDS. *There are about 23 different amino acids.*

   How many protein molecules containing 3 amino acids can be constructed from 2 different amino acids? Designate the amino acids "A" and "B," and use these symbols to illustrate various protein molecules.

   AAA AAB ABA BAA
   BBB BBA BAB ABB

   How many protein molecules containing 3 amino acids can be con-

structed from 3 different amino acids? Work this out in a similar manner to the previous problem.

Develop the concept that since protein molecules can contain chains of hundreds or thousands of the 23 amino acids in various combinations, there are a staggering number of different proteins.

Summary

1. Why are proteins needed for the formation of new protoplasm?
2. What elements are present in protein that are not found in carbohydrates and fats?

Homework

1. Why is a diet of candy, cake, and soda bad for one's health?
2. Prepare a list of protein-rich foods included in your diet during the past week.

Materials

Sample of meat	Glass plate	Tongs

22. WHAT FOODS WILL GIVE US ALL THE ESSENTIAL VITAMINS?

Outcomes

- Vitamins keep the body working properly.
- Vitamins prevent deficiency diseases.

Motivation

Tell the story of the famous experiment of Dr. Frederick Hopkins, who in 1906 selected a large number of healthy rats, recorded their weights, and then fed them diets consisting of five pure nutrients (sugar, starch, protein, fats, minerals, and water). Within a short time, the rats stopped growing, slowly lost weight, and then died.

Have pupils make tentative conclusions based on the results of this experiment. Elicit the following:

1. The normal diet of the rats contained something that the five pure nutrients did not supply.
2. The missing substance is necessary for life.
3. The missing substance is one or more *vitamins*. (Point out that *vita* means life.)

Development

1. Exhibit Vitamin Chart and/or distribute duplicated chart.

VITAMIN CHART

Vitamin & Sources		Uses in Body	Effects of Deficiency
A	Fish-liver oils Green, yellow vegetables Milk, cheese	Growth Health of eyes, skin, teeth	Slowed growth Infections Night blindness* Xerophthalmia*
B Complex	Seafood Green vegetables Liver Soybeans Whole-grain bread	Growth Helps body use sugar, starch Health of heart, nerves, skin, mouth, eyes, muscles, stomach Health of blood	Slowed growth Loss of appetite, weight, energy Poor skin, eyesight Mental illness Pellagra (lack of niacin)* Poor digestion Beri-beri (lack of Vit. B)*
C	Citrus fruits Green vegetables	Growth Health of teeth, gums, blood vessels	Sore gums Bleeding Bruising easily Scurvy*
D	Sunlight Egg yolks Enriched milk Liver Fish Fish-liver oils	Growth Building bones, teeth Helps body use minerals, including calcium, phosphorus	Soft bones Tooth decay Rickets*
K	Green vegetables Soybeans Milk Eggs	Helps blood form scabs, clots to stop bleeding Health of liver	Continued bleeding of cuts* Hemorrhages

*Deficiency disease

How many B Vitamins are there? What is meant by the B Complex? Elicit that there are several B Vitamins. Identify some of these as niacin, thiamin, and riboflavin.

2. How are vitamins used by the body? Elicit that each vitamin plays an important role in the functioning of the body. Vitamins are credited with the prevention of certain diseases. They are called *deficiency diseases*. Elicit that each is caused by a deficiency of a specific vitamin.
3. Does every food contain all the vitamins necessary for good health? Elicit that most foods are sources of only one or two vitamins. Discuss the need for a varied diet. Why is milk called "the perfect food"? Elicit that milk contains several vitamins as well as several nutrients.
4. *Why is Vitamin D called "the sunshine vitamin"? Explain that Vitamin D is manufactured in the skin when the skin is exposed to sunlight. Why is milk enriched with Vitamin D? Elicit that by drinking enriched milk one can be sure of a supply of Vitamin D, even during periods when the skin is not exposed to sunlight.*

Summary

1. Why is it important to include all essential vitamins in our diet?
2. What is a deficiency disease?
3. *Some vitamins may be stored in the body, while others, like Vitamin C, are excreted in the urine. Why is it important for us to include citrus fruits or juices in our diet each day?*

Homework

Have pupils prepare reports about vitamins on the following topics:
1. Why British Sailors Are Called "Limeys"
2. How Dr. Lind First Prevented Scurvy
3. The Work of Dr. Goldberger With Pellagra
4. How Dr. Eijkmann and His Chickens Found the Cure for Beri-Beri

Materials

Vitamin Chart (S-1, 12-1998)

Mimeographed vitamin list

23. HOW DO MINERALS HELP US CARRY OUT OUR LIFE ACTIVITIES?

Outcome

- Minerals are important for body health and energy. Some important minerals are calcium, phosphorus, iron, sulfur, and iodine.

Motivation

Challenge pupils by asking, "What is an atomic cocktail?" Some pupils may know that it is a radioactive solution (refer pupils to Grade 7: Chemistry for review of radioactivity) employed in the detection and treatment of thyroid conditions. Continue the discussion of mineral isotopes. How do we learn for which part of the body a chemical will be used? Elicit that by having a person take a radioactive form of the chemical we can determine to which part of the body it goes by the use of a Geiger counter.

Development

1. How is the mineral iodine used by our bodies? Elicit that it is necessary for healthy functioning of our thyroid glands.
   Exhibit a container of iodized salt. Point out that iodine is added to prevent a deficiency of this mineral.

2. Duplicate and distribute the table of minerals. (See page 218.)

   Use the chart to promote discussion of these questions:

   a. Which minerals were included in your diet today?

   b. What is meant by anemia?

   c. If a doctor finds a patient anemic, what two foods might he prescribe?

   d. Which two minerals are needed to build strong bones and teeth?

   e. What mineral found in the home is enriched by another mineral?

   f. If a doctor injected radioactive sulfur into the blood, where in the body might it later appear in large amounts?

   g. What are some foods which are necessary to aid blood clotting?

   h. Why is iodized salt important in inland areas? (Hint: Iodine is found in seafood.)

Name & Symbol		Sources	Value to Body
Calcium	Ca	Milk, cheese, green vegetables, cereals, citrus fruits	Helps build strong bones, teeth Helps blood to clot
Phosphorus	P	Meats, milk, cheese, cereals, poultry, seafood, eggs	Builds strong teeth, bones, and healthy nervous system
Iron	Fe	Liver, red meat, eggs, spinach, fruits, vegetables, cereals	Builds red blood cells. Prevents some forms of anemia
Sulfur	S	Meats, poultry, fish, egg yolk, peas, beans	Builds healthy skin, hair, nails
Iodine	I	Seafood, vegetables, iodized salt	Helps control rate of use of energy. Needed for healthy thyroid gland
Sodium & Potassium	Na K	Table salt	Important constituent of blood. Needed for proper functioning of cellular activities

Note: Minerals cannot be used by the body unless they are in a soluble form.

3. *Have pupils recall the test for minerals whereby a food is heated until an ash remains. Demonstrate that there are other tests for specific minerals.*

   a. *With a wire loop, heat some sodium chloride crystals in a Bunsen flame. With another wire loop, heat some potassium chloride crystals in the flame. What are the distinctive colors of the flame, when each is heated? Elicit that the sodium produces a yellow flame and the potassium, a red-violet flame. Elicit that this is a test to identify elements as well.*

   b. *To a solution of sodium chloride, add several drops of silver nitrate solution. The presence of chloride ion is shown by the formation of a white precipitate which is insoluble in dilute nitric acid.*

Summary

1. How can we determine where a mineral is used in our body?

2. Why is salt iodized?
3. Which vitamin and mineral act together to aid blood clotting?

Materials

Iodized salt
2 platinum wire loops
Sodium chloride
Silver nitrate solution
Duplicated mineral charts
Potassium chloride
Sodium chloride solution
Dilute nitric acid

24. HOW CAN WE INSURE PROPER FUNCTIONING OF THE SYSTEMS OF OUR BODY?

Outcome

- A balanced diet is one that includes all the necessary nutrients in quantities sufficient to maintain good health.

Motivation

Pose the question, "How can we make sure our bodies are supplied with all the essential nutrients?" Elicit that a balanced diet should include all the nutrients essential for life.

What is the role of the school dietitian in preparing school lunches? Elicit that the dietitian prepares menus which supply all essential nutrients.

Development

1. Duplicate and distribute the Basic Four chart: (See page 220.)

   Have pupils use this chart to prepare a balanced two-day menu.

   Pose the question, "Does your menu supply you with all the essential nutrients?" (Have pupils utilize previous class experiences to determine nutrient content of foods.)

   Does the diet contain all the essential vitamins?

   Does it supply all the essential minerals?

BASIC FOUR

1. **MILK GROUP:** milk, cheese, butter, and ice cream
2. **BREAD-CEREAL GROUP:** bread, macaroni, noodle, rice, spaghetti, pizza, waffles, and pancakes
3. **MEAT GROUP:** meat, chicken, fish, eggs, nuts, dry beans, and peas
4. **VEGETABLE-FRUIT GROUP**

YOU SHOULD HAVE (DAILY)

Group 1. Four or more cups of milk; butter, cheese, or ice cream can take the place of a cup of milk

Group 2. Four or more helpings

Group 3. Two or more helpings

Group 4. Four or more helpings; one citrus fruit and one green or deep yellow vegetable are necessary

2. Does the diet meet your energy requirements? Tell pupils that energy requirements vary with age, weight, sex, activity, and occupation. The energy value of foods is measured in Calories. Junior high school boys require about 30 Calories per pound of body weight, girls about 23 Calories. Who needs more Calories, an 80-pound boy or 100-pound girl?
3. Bulk and roughage are necessary to satisfy hunger and for the proper elimination of wastes. Leafy vegetables are good sources of bulk and roughage. Which did you include in your menu?

Summary

1. Why is a meal which contains bread, rice, and spaghetti a poorly planned meal?
2. Why are foods from each group needed for a balanced diet?
3. What foods would you not include in your evening meal if yo had pizza and soda for lunch?
4. Can you live on bread alone?

Homework

1. Which individual in each of the following pairs has the highe energy requirement? Why?

   a. Baseball player — salesman
   b. Teacher — construction worker
   c. Junior high school student — college student
   d. 160-pound man — 120-pound woman
   e. Typist — nurse

2. What is the definition of a balanced diet?

3. Did you eat a balanced diet today? What did it contain?

Materials

Duplicated chart, "Basic Four"

REINFORCEMENT AND REVIEW (14—24)

Note: The instructor may select the most suitable of the following suggestions for review and reinforcement.

Audio-Visual Aids

Films (16mm)

Food: Energy from the Sun (AV List 229.45) Green plants utilize the energy in sunlight to make food in their leaves.

Photosynthesis (AV List 32815.13) Describes the process of sugar production by green plants on the molecular level.

Nutrition and Metabolism (BAVI) Explains the five classes of chemical substances which comprise all foods, and shows how they are essential to body growth and repair.

How Green Plants Make and Use Food (AV List 293.78) Four essentials used by green plants in photosynthesis.

How the Body Uses Energy (AV List 295.261) Energy is required for physical activity and also to maintain physiological processes.

How Green Plants Make Food (AV List 293.786) How green plants make food in the process of photosynthesis.

FILMSTRIPS

Disease and Diet (Vitamins) (AV List 37470.1) Scurvy, beri-beri, tests with animals for various deficiency diseases.

Our Food (AV List 37367.33) Importance of food as a nutrient.

Matching

Match the items in column A with the vitamins and minerals i column B. Items in column B may be used more than once.

A

---- 1. Beri-beri
---- 2. Anemia
---- 3. Scurvy
---- 4. Sunshine vitamin
---- 5. Night blindness
---- 6. Mineral for building strong bones
---- 7. Enriched milk
---- 8. Citrus fruits
---- 9. Rickets
---- 10. Seafood

B

a. Vitamin A
b. Vitamin B_1
c. Vitamin C
d. Vitamin D
e. Vitamin K
f. Calcium
g. Iron
h. Iodine
i. Sulfur

Student Projects

There are many pupil project ideas in the area of photosynthesis an food production by green plants.

1. How does the wavelength of light (color) affect photosynthesis?
2. *How does polarized light affect the process of photosynthesis?*
3. How does artificial light affect the process of photosynthesis?
4. *What factors control starch synthesis form glucose in green plant* (See NYS Biology Handbook—1.38.)
5. What happens during the "dark reaction" in photosynthesis?
6. How can chloroplast pigments be separated?
7. How does light intensity affect the rate of photosynthesis?
8. Is carbon dioxide necessary for photosynthesis?

SUGGESTED UNIT EXAMINATION: BIOLOGY

The following are not intended as a diagnostic tool or comprehensive measure of unit outcomes. They may serve for review purposes, as a source of unit examination, or in any way deemed desirable.

1. Nonliving things differ from living things because nonliving things are *not:*
   a) affected by heat
   b) able to adjust to stimuli
   c) made of various chemicals
   d) made of solids, liquids, and gases.

2. To provide energy a nutrient must combine with:
   a) water b) minerals c) oxygen d) carbon dioxide.

3. The objective of a microscope is:
   a) close to the eye
   b) the part that holds the slide
   c) the part that adjusts the light
   d) the lens furthest from the eye.

4. A microscope has 10x and 45x objectives and a 10x ocular. The highest magnification possible is:
   a) 45 b) 55 c) 450 d) 4500.

5. All living things observed under the microscope had:
   a) green-colored bodies c) cell walls
   b) cell membranes d) organs for locomotion.

6. From your study with the microscope, you can conclude that all living things:
   a) are composed of different materials
   b) are composed of cells
   c) show no resemblance to each other
   d) live in the same surroundings.

7. Most foods contain:
   a) only one nutrient c) all the vitamins and nutrients
   b) all the nutrients d) more than one nutrient.

8. Milk helps growing boys and girls because it:
a) is our only source of iron
b) is the best source for vitamin C
c) contains many important nutrients
d) is easily purchased.

9. The nutrient present in smallest amounts in foods is:
a) carbohydrates b) fats c) proteins d) vitamins.

10. Lugol's solution is used to test for:
a) starch b) sugar c) protein d) fat.

11. Benedict's solution is used to test for:
a) starch b) sugar c) protein d) fat.

12. Biuret solution is used to test for:
a) starch b) sugar c) protein d) fat.

13. A nutrient which contains only the 3 chemical elements, carbon
hydrogen, and oxygen is:
a) protein b) water c) vitamin d) sugar.

14. A nutrient which can be found in foods without the use of
chemical test is:
a) starch b) sugar c) protein d) fat.

15. A food which is a good source of vitamin C is:
a) chicken b) bread c) beef d) lemon.

16. A good source of protein is:
a) spinach b) rice c) lettuce d) pork.

17. A superior source of calcium for our diets is:
a) liver b) seafood c) eggs d) cottage cheese.

18. The substance needed by our body in largest quantity as a growt
promoting material is:
a) protein b) fat c) iron d) iodine.

19. The energy value of foods is measured in:
a) grams b) Calories c) meters d) degrees Celcius.

20. A valuable source of dietary iodine is:
a) seafood b) cereals c) enriched milk d) liver.

21. A vitamin which is not stored by the body when taken in excess is:
a) vitamin A b) vitamin B_1 c) vitamin C
d) vitamin D.

22. Which of the following represents the recommended caloric need per day for a 100 pound, thirteen-year-old boy?
a) 1800 Calories b) 2500 Calories c) 3000 Calories
d) 4500 Calories.

23. A good source of nutritional iron is:
a) butter b) margarine c) pizza d) liver.

24. A vitamin produced by the skin during exposure to the sun is:
a) vitamin A b) vitamin B_2 c) vitamin C
d) vitamin D.

25. A disease due to a deficiency of vitamin C is called:
a) beri-beri b) rickets c) scurvy d) pellagra.

26. Cells without nuclei are:
a) muscle cells c) red blood cells
b) white blood cells d) nerve cells.

27. The scientist who first observed "cells" in cork was:
a) Brown b) Hooke c) Van Leeuwenhoek
d) Schwann.

28. The living material in a cell, surrounding the nucleus is:
a) cell membrane b) cell wall c) cytoplasm
d) vacuole.

29. One difference between a plant cell and an animal cell is the:
a) nucleus b) cell wall c) cytoplasm
d) cell membrane.

30. The green pigment in plant cells is found in bodies called:
a) nuclei b) chromosomes c) chloroplasts d) genes.

31. Factors carrying heredity of a cell are found in the:
a) cell wall b) cytoplasm c) chloroplasts d) nucleus.

32. Digested foods and oxygen enter the cell through the:
a) nucleus b) cytoplasm c) cell membrane
d) vacuole.

33. The process by which green plants manufacture carbohydrates is called:
a) osmosis b) growth c) photosynthesis d) excretion.

34. When green plants manufacture carbohydrates, an important waste product released into the air is:
a) carbon dioxide b) nitrogen c) sunlight d) oxygen.

35. The raw materials green plants use to manufacture carbohydrates are:
a) CO_2 and O_2
c) CO_2, H_2O and O_2
b) H_2O and O_2
d) CO_2 and H_2O.

36. A group of similar cells performing the same function is called:
a) a tissue b) an organ c) a system d) an organism.

37. The main supporting tissues in our body are bone and:
a) nerve b) blood c) muscle d) cartilage.

38. A tissue adapted for carrying messages is:
a) nerve b) blood c) muscle d) bone.

39. A tissue which aids the body to move is:
a) blood b) muscle c) epithelial d) cardiac muscle.

40. A test made for the purpose of comparison is called:
a) an experiment
c) a physical change
b) a chemical change
d) a control.

41. Including "enriched milk" in one's diet prevents the deficiency disease called:
a) beri-beri b) rickets c) scurvy d) pellagra.

42. Night blindness is caused by a dietary lack of:
a) vitamin B_{12} b) vitamin E c) vitamin K
d) vitamin D.

43. An example of a digestive organ is:
a) heart b) lungs c) intestines d) ear.

44. The longest cells in the body are:
a) nerve cells b) muscle cells c) bone cells d) epithelial cells.

45. Anemia is caused by a dietary lack of:
a) calcium c) vitamin A

b) iron d) vitamin D.

46. The green pigment in plant cells is called:
a) magnesium b) cellulose c) chlorophyll d) iodine.

47. An example of a one-celled animal is:
a) spirogyra b) amoeba c) bacteria d) yeast.

48. The wood we use is composed of:
a) plant cytoplasm c) plant nuclei
b) plant cell walls d) plant vacuoles.

49. Which of the following is not a basic need of all living things?
a) food b) water c) carbon dioxide d) oxygen.

50. We need bulk and roughage in our diet to aid in:
a) using vitamins c) supplying minerals
b) disposal of solid wastes d) supplying vitamin K.

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Unit IV

EARTH SCIENCE

Changing Crust of the Earth

Rocks and Minerals
The Changing Earth
The Importance of Fossils

ROCKS AND MINERALS

Suggested Lessons and Procedures

1. WHAT DO WE KNOW ABOUT THE STRUCTURE OF THE EARTH?

Outcomes

- The earth consists of three main parts: a solid surface called the lithosphere, a liquid portion called the hydrosphere, and a gaseous layer called the atmosphere.
- The earth is divided into four layers: crust, mantle, outer core, inner core.
- *As we move toward the center of the earth, the temperature and pressure increase.*
- *The earth, at one stage of development, was in a molten state. Lighter liquids floated on top of heavier ones.*

Motivation

Hold up a globe. Ask, "Why is the term *Earth* a poor name for our planet?"

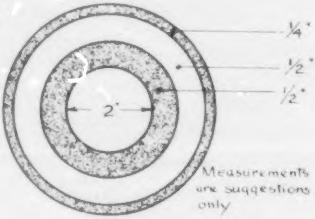
Development

1. Show recent pictures of the earth taken by astronauts, and elicit from the class that the earth is a solid sphere covered by about 70% water and is surrounded by a gaseous envelope called the

atmosphere. Identify the solid crust as the *lithosphere* and the liquid portion as the *hydrosphere.*

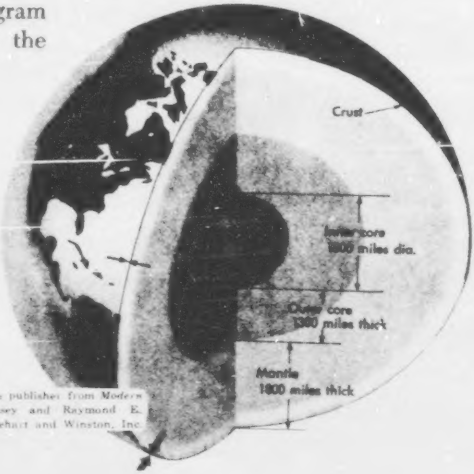
2. Display a ball of clay which has been prepared as shown in the diagram. (Use different colors for each layer.) Tell the pupils that it represents the earth. Ask "How can we find out what is inside this ball without cutting it in half?" Lead pupils to suggest pushing a plastic or glass tube through the clay. Withdraw the tube and have pupils observe the layer of clay. Point out that this method of boring is used by geologists to study the interior of the earth.

NOTE: Lubricate the tube with water; warm clay with palms of the hands, and push the tube through with a twisting motion. Use paper toweling around end of tube to protect the hands.



3. Mention Project Mohole and elicit from the class that the best place to drill through is in the ocean because there is less land. Tell the class how borings and the use of earthquake waves are being used to gain information about the earth's interior.

4. Show pupils a diagram or transparency of the earth's interior.



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Have pupils draw the diagram of the earth in their notebooks, showing crust, mantle, outer core, inner core.

5. Draw the following chart on the board:

ZONE	THICKNESS	COMPOSITION
Crust	8-30 miles	Solid rocks, such as granite and basalt
Mantle	1800 miles	Solid heavier rocks, such as basalt and iron (rich rocks)
Outer core	1300 miles	Melted iron and nickel, very high temperatures
Inner core	800 miles	Solid iron and nickel, extremely high temperatures (3000°-6000° C)

Ask the class what they can conclude about the density of granite and basalt from the location of these rocks. Point out that in the molten state the heavier or denser basalt settles below the lighter granite.

Summary

1. What are the three main parts of the earth?
2. What are the four layers of the earth?
3. *Describe the characteristics of the crust, mantle, outer core, and inner core.*
4. Why are borings so useful in the study of the earth's interior?
5. What methods are now being used to study the earth's interior?
6. *Could the mantle be denser than the core? Explain your answer.*
7. *What are some ways to prove that the earth is not hollow?*

Homework

1. What are the major topics in the study of earth science?
2. Why does the temperature increase as we go deeper into the earth's crust?

3. Why is Jules Verne's novel about a group of people's journey to the center of the earth highly improbable?
4. *Write a short report on Project Mohole.*
5. *Write a short report on IGY.*

Materials

World globe
Prepared ball of clay (layers of different colors)
6″ plastic or glass tube
Paper toweling
Diagram or transparency of cross-section of earth

2. WHAT SUBSTANCES CAN BE FOUND WITHIN THE EARTH'S CRUST?

Outcomes

- Most rocks that form the crust of the earth are made up of minerals.
- A mineral is a substance found in nature, chiefly of nonliving (inorganic) origin, having definite physical characteristics and definite chemical composition.
- *A mineral is formed when elements combine in nature.*
- An ore is a mineral or group of minerals containing a worthwhile metal that can be extracted economically.

Motivation

Let the class examine large specimens of granite, pegmatite, schist, and conglomerate with hand lenses. Ask the class to describe in their own words the appearance of each of the rocks. "Do they all look alike?"

Development

1. Elicit from the class that rocks are composed of many small particles called minerals. Ask the class to define a mineral.

2. Recall from the chemistry unit that all matter is composed of elements. Point out that even though the crust of the earth is composed of about 100 elements, only eight of them make up 98% of the crust. Display the following chart:

EARTH'S CRUST		
ELEMENT	CHEMICAL SYMBOL	PERCENTAGE BY WEIGHT
Oxygen	O	46.71
Silicon	Si	27.69
Aluminum	Al	8.07
Iron	Fe	5.05
Calcium	Ca	3.65
Sodium	Na	2.75
Potassium	K	2.58
Magnesium	Mg	2.08

3. Have the class note that oxygen makes up almost 50% of the crust. Ask the class to explain how it is possible for oxygen, which is a gas, to make up more than 50% of the crust. Display large samples of quartz, (silicon dioxide, SiO_2); calcite (calcium carbonate, $CaCO_3$); hematite (ferric oxide, (Fe_2O_3). These are a few samples of compounds of oxygen. "Can you name others?"—aluminum oxide (bauxite).

   Point out that a mineral is a natural substance, usually formed from a nonliving substance, having definite physical characteristics (color, luster, hardness, etc.) and chemical composition, e.g., silicon dioxide.

4. *By means of a board diagram or transparency, review what happens when sodium combines with chlorine. Display a specimen of halite. Elicit that this mineral is the result of the combination of many chlorine and sodium atoms. Point out that all minerals are a result of the combination of metals and nonmetals. Indicate tha when the molecules arrange themselves in regular pattern, a crysta*

results which is special for that mineral. Display crystals of quartz, pyrite, galena, or any gem stones that may be worn as jewelry. It is not necessary to identify the crystalline shape.

5. Display specimens of bauxite, galena, hematite, chalcopyrite. Point out that these are called ores. Tell class that an ore is a mineral or group of minerals containing an element that can be extracted economically. Illustrate the process by which an element is extracted from its ore. Place some copper oxide and powdered charcoal in a test tube and heat thoroughly. Pour the mixture into a beaker of water. The pieces of shiny copper will fall to the bottom of the beaker and the charcoal will float at the top.

   Write the word and symbol equations on the board.

   Copper oxide + carbon → copper + carbon dioxide

   $$2CuO + C \rightarrow 2Cu + CO_2$$

Summary

1. What is a rock?
2. What is a mineral?
3. Draw a chart showing eight elements that make up most of the earth's crust.
4. Name 3 important minerals; list the chemical formula of each.
5. *How are minerals formed?*
6. What is an ore?
7. *Describe a method used to remove a metal from its ore.*

Homework

1. Why are there so many different types of minerals?
2. Explain why the following are or are not considered minerals
   a. sugar
   b. gold
   c. ice
   d. pearls
   e. coal and oil
   f. synthetic rubies
3. Match the following ores with their metals.
   a. bauxite
   b. hematite
   c. cinnabar
   d. galena

   iron
   lead
   mercury
   aluminum

4. *How are crystals formed in the earth?*
5. *How do you account for the differences in price among minerals?*
6. *What is our source of phosphorus? Is it an ore?*

Materials

Granite
Pegmatite
Schist
Conglomerate
Quartz
Calcite
Hematite
Pyrite
Bauxite
Chalcopyrite
Test tube
Stand
Bunsen burner
Copper oxide or lead oxide
Charcoal
Beaker

3. WHAT ARE SOME PROPERTIES THAT HELP IDENTIFY MINERALS?

LABORATORY LESSON

Outcomes

- Minerals can be identified by physical properties, such as color, luster, hardness, streak, and density.
- More than one property of a mineral must be used to identify it.
- *Other properties such as cleavage and density help identify a mineral.*

Motivation

Display a specimen of pyrite ("fool's gold") or chalcopyrite. Ask students to describe it. Ask, "Why might it be mistaken for gold?"

Development

1. Elicit that to identify a mineral correctly, a geologist must make use of a combination of properties exhibited by a mineral.

2. Distribute materials to each group of pupils.

NOTE: Number materials before distributing them and place corresponding numbers on Worksheets and specimens.

Homework

1. Why can't a geologist depend on only one test to identify a mineral?
2. How can magnetism be used as a method of identifying a mineral?
3. Complete this chart:

MINERAL	COLOR	HARDNESS	LUSTER	STREAK
Galena				
Calcite				
Hematite				
Pyrite				

4. *How can you account for the fact that arrangement of the atoms in a mineral helps to explain its*
   a. crystalline shape
   b. hardness
   c. cleavage
   d. ratio of weight to volume (density)

Materials

Pyrite or chalcopyrite
Mica
Quartz

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 3

Problem: What are some properties that can be used to identify minerals?

Materials

Samples of: Galena Milky quartz Talc Iron nail Halite
Sulphur Rose quartz Hematite Calcite Mica Pyrite
Glass plate (4" x 4")
Streak plate (unglazed porcelain)

Procedure and Observation

1. Color is present in most minerals, and most have several colors due to the chemicals in them. A few minerals always have the same color.

   a. Look at sulphur (#--------) What is its color? ------------
   Look at galena (#--------) What is its color? ------------
   The colors of these two minerals are always the same.

   b. Look at rose quartz (#--------) What is its color? ------------
   Look at milky quartz (#--------) What is its color? ------------
   Why can't we use color alone to identify a mineral?

2. Luster is the way a mineral reflects light from its surface. You have studied some words in chemistry to describe luster: *dull, waxy, metallic, glassy*. Use these words to describe the luster of:

   pyrite (#------) ------------ talc (#------) ------------
   hematite (#------) ------------ galena (#------) ------------
   rose quartz (#------) ------------ calcite (#------) ------------

3. Hardness is the ability of one substance to scratch another. A mineral is said to be harder than any other mineral it *can scratch* and *softer* than any other mineral that can scratch it.

   a. Try to scratch the talc with the iron nail.
   Which is harder—talc or iron? ------------

   b. Try to scratch the calcite with the talc.
   Try to scratch the calcite with the nail.
   Is calcite harder than talc? ------------ Than iron? ------------

   c. Try to scratch the quartz with the iron nail.
   Try to scratch the glass plate with the quartz.
   Try to scratch the glass plate with the nail.

   d. List these: calcite, glass plate, iron nail, quartz, and talc in decreasing order of hardness.

4. Streak is the color of the powder in a mineral. A streak plate is a piece of unglazed porcelain. Rub these minerals on the streak plate: calcite, pyrite, hematite, galena.

MINERAL	COLOR OF MINERAL	COLOR OF STREAK
Calcite		
Pyrite		
Hematite		
Galena		

5. *Density—A mineral can be identified by comparing its density (weight per unit volume) to the density of mineral of the* SAME SIZE.

   a. *Compare the density of sulphur to galena.*

      Which is denser? ________________

   b. *Compare the other specimens of the same size. List them in order of density (weight for size). Name the heaviest mineral first.*

      1.________ 2.________ 3.________ 4.________ 5.________

6. *Cleavage is the capacity of minerals to break in different ways. The samples you are looking at were broken from larger samples.*

   Minerals can split along smooth, flat surfaces in one or more directions. Cleavage is the term used to describe this splitting.

   a. *Examine mica (#______). How does the mica split or break off?*__________ *We say that it has cleavage in one direction.*

   b. *Examine galena. Notice its boxlike appearance. We say that it has cleavage in three directions. Why?*

   c. *Examine calcite; describe its cleavage.*

Summary

List the various methods used by scientists to identify minerals.

4. HOW ARE IGNEOUS ROCKS FORMED?

Outcomes

- Igneous rocks were formed from molten material that solidified on cooling.
- *Crystal size of minerals in igneous rock depends upon the cooling rate of the magma.*

Motivation

Distribute specimens of pegmatite, quartz, feldspar, and mica and a hand lens to students. Ask pupils to examine pegmatite and describe it. Guide them to see that it is composed of different particles.

Development

1. Recall the fact that rocks are mixtures of minerals. Have students try to identify the minerals in pegmatite. Tell them to use quartz, feldspar, and mica for comparison.
2. Ask the students to suggest the ways in which this rock might have formed. Point out that the earth in its early history was in a hot, molten state with all the minerals mixed together. The earth's surface then cooled and hardened. Tell the class that this type of rock formed from molten material that has cooled is called igneous rock. *Igneous* means fire in Greek. Ask where we may find molten rock today. Show pictures of volcanoes. Elicit that the molten rock which pours out upon the surface of the earth is called *lava*. This same material within the earth is called *magma*.
3. Discuss why we believe that the first type of rock to cover the earth was probably igneous rock.
4. *Demonstrate that the crystal size of materials in igneous rocks depends upon the cooling rate of the magma. Place a teaspoonful of sulfur in a porcelain dish. Heat it gently until the sulfur melts and turns a honey-brown color. Then remove the dish from the heat and let the sulfur cool to room temperature. Repeat the same procedure but this time pour the melted sulfur into cold water. Have the class examine the needle-like crystals formed from the slow cooling*

process. (A hand lens will produce a better view of the crystals.) Elicit that this demonstration shows how igneous rocks are formed and that a slow cooling time produces large crystals.

Summary

1. What are rocks?
2. How are igneous rocks formed?
3. What is the difference between magma and lava?
4. *What determines the size of the crystals in an igneous rock?*
5. *Why do we believe that igneous rock was the first rock to cover the earth?*

Homework

1. The word *igneous* comes from Greek and means fire. Why is this a good name for igneous rocks?
2. How does molten material reach the earth's surface?
3. *If you do the following experiment, does it result in the formation of crystals? Dissolve an ounce or two of table salt or sugar or epsom salts in a half pint of water. Pour the solution into a shallow bowl. Dip one end of a string into water and have the other end hang (attached with tape) over the edge of the bowl. Allow the solution to evaporate slowly over a period of a few days. (Try it yourself to see what really happens.)*

Materials

Hand lens
Pegmatite
Feldspar
Mica
Quartz
Sulfur
Evaporating dish
Tripod
Bunsen burner
Beaker
Additional rock samples

5. HOW CAN WE IDENTIFY IGNEOUS ROCKS?

LABORATORY LESSON

Outcomes

- Igneous rocks are recognized and classified by their individual properties and the minerals they contain.
- *The texture of an igneous rock can tell us where the rock was formed.*

Motivation

Display large specimens of granite and gabbro. Tell the class that these are different igneous rocks. Elicit from the pupils that one good method of classifying igneous rocks is by differences in color.

Development

1. Display large samples of pegmatite and felsite or pumice. Ask, "May we use the size of the minerals within the rocks as a method of identification?"
2. Distribute materials to groups of pupils. Guide the pupils in performing a laboratory experiment to identify igneous rocks.

Homework

1. What determines the color of an igneous rock?
2. What is the difference between gabbro, basalt, and obsidian?
3. Why are some igneous rocks fine-grained and others coarse-grained?
4. How is it possible to predict where an igneous rock was formed?
5. If you discovered an area covered with obsidian, what might have existed in this region? Explain why you come to this conclusion.

Materials

Specimens of:

Granite, gabbro, pumice, basalt, felsite, pegmatite, obsidian

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 5

Problem: How can we identify igneous rocks?

The rocks you will see today are called *igneous* rocks. They formed when the molten *magma* cooled. One of the ways we identify a rock is by the presence of certain minerals in it. You may fine quartz, mica, and feldspar which will help you recognize each rock.

Materials

Minerals: quartz, mica, feldspar
Rocks: pegmatite, granite, obsidian, pumice, basalt
Hand lens (10x)
400ml beaker, ⅓ full of water

Procedure and Observation

1. Examine granite (#______) with a hand lens. Compare the pieces in it with your specimens of quartz (#____), mica (#____), and feldspar (#____).
   a. The material in the granite (rock) that is flaky and black might be ______.
   b. The mineral that looks like broken glass and sparkles in the light is ______.
   c. The pieces in the rock that look pearly, flat, and sometimes pink or salmon-colored are probably ________.

2. Look at pegmatite (#____) with the hand lens.
   a. Name the minerals found in this rock _____________.

3. Compare the size of the crystals in granite and pegmatite.

4. Observe the basalt (#____).
   a. Describe the color of this rock.
   b. Using a hand lens, tell if you can see any crystals in this rock. __________

5. How can you tell the difference between basalt and granite? ______________

6. Examine obsidian (#____).
   a. Describe its appearance. ____
   b. Can you see any crystals? ________ Why? ____________________________

7. Look at pumice (#____).
   a. Describe its appearance. ____
   b. Describe its color. ____
   c. Put the rock into the beaker of water. Does it float? ______ Why? ________

Conclusion

1. Which rock had the largest crystals?
2. Which rock had smaller crystals?
3. Which of the two rocks listed above cooled faster?
4. Explain why you picked this rock.
5. Of all the rocks you examined, which cooled the fastest and which cooled the slowest? Explain your answer.
6. What causes some igneous rocks to appear dark in color and others light?
7. List two ways of identifying igneous rocks.
8. Explain how you would determine if an igneous rock formed on the surface of the earth or deep inside it.
9. Divide your samples into two groups and list each rock under the proper heading.
   a. Rocks formed inside the earth. b. Rocks formed on the surface.
10. How do you think the pumice developed holes? (Look at a slice of white bread. How did the holes get into it?)

6. HOW ARE SEDIMENTARY ROCKS FORMED?

Outcomes

- Sedimentary rocks may be formed:

  From fragments of other rocks which are compressed and cemented together,

  When water containing dissolved minerals evaporates,

  From the remains of plants and animals.

- *The durability and color of some sedimentary rocks depend upon the cementing material.*

Motivation

Mix some plaster of Paris and fish tank gravel in a paper cup. Add enough water to make the plaster a creamy consistency. Let the mixture stand for about 5 minutes. Rip the paper away and display the newly formed rock.

Discuss the cementing effect of various materials and how concrete is prepared.

Demonstration

1. Tell the class that in the ocean there are dissolved natural cements that bind particles of rocks (gypsum, hematite, calcite, silica) together. Elicit that the rocks that covered the earth in its early history were igneous and that they were broken down by wind and water and were recemented later.

2. Let the pupils examine specimens of conglomerate, sandstone, and shale. Tell them the name of each rock. Point out that these are samples of sedimentary rocks. Have pupils suggest how these rocks were formed.

3. *Break the plaster of Paris by hand. Elicit from the pupils that the durability of the rock depends upon the cement used to hold the particles together.*

4. *Display two sandstones of different colors and elicit that the color of this rock is dependent upon the makeup of the cement.*

5. At the beginning of the period add 40 grams of sodium chloride to 100 grams of water in a beaker and boil the solution until all of the water evaporates. Show the pupils that the salt has formed at the bottom and sides of the beaker. Ask pupils where they would find a similar situation of salt or other minerals dissolved in a liquid. Elicit that the continuous evaporation of water from salt lakes, shallow bays, and inland seas causes mineral deposits such as sodium chloride, gypsum, and limestone to form. Point out that these are other forms of sedimentary rocks.

6. Display large rock samples of coquina, shell limestone, and different types of seashells. Have pupils suggest how these rocks were formed. Elicit from the pupils that the seashells are broken into fragments by the action of waves and pile up one upon another. These pieces form layers which are compressed and cemented together. Point out that sedimentary rocks are formed when smaller

particles collect or settle upon each other (sediments) and are cemented and compressed together.

7. *Display samples of coal and show fossils of ferns. Ask how coal is formed.*

Summary

1. Describe three ways sedimentary rocks are formed.
2. How can rock particles be stuck together to form rocks?
3. Why is water important for development of sedimentary rocks?
4. A few days after a snowstorm you can walk on top of the snow mounds. How does this in some way resemble the formation of sedimentary rocks?

Homework

1. The sedimentary rock, shale, is often called siltstone or mudstone. Explain why.
2. In comparison to igneous rocks, why are sedimentary rocks considered new?
3. Name a man-made sedimentary rock. Explain how this rock is made.
4. *Explain which rocks are harder to break apart—igneous or sedimentary.*
5. *Mix some soil, sand, and pebbles with some water in a jar. Stir the mixture thoroughly. Watch as the particles settle. Which one settles first? Explain why.*

Materials

Dish
Plaster of Paris
Fish tank gravel
Paper cups (7 oz.)
Concrete
Sodium chloride
Beaker
Seashells

Specimens of:
- Sandstone
- Shale
- Coquina
- Shell limestone
- Conglomerate

7. HOW CAN WE IDENTIFY SEDIMENTARY ROCKS?

LABORATORY LESSON

Outcomes

- Sedimentary rocks can be identified by the kind and size of their rock, particles, the presence of the remains of once living plants and animals, and their reaction to acids.
- *The smaller or finer the rock particles of a sedimentary rock, the more tightly packed they will be.*

Motivation

Display a large piece of concrete and ask the class to identify it. Ask, "What are the identifying characteristics of concrete?"

Development

1. Display a large specimen of conglomerate and sandstone. Tell the pupils that these are specimens of sedimentary rock. Ask the pupils to suggest methods of identifying them. Elicit that determining the size of the particles is one method.
2. Display a specimen of calcite. Place a drop of diluted hydrochloric acid on it. Point out that this is a specimen of calcite and that it will always bubble when hydrochloric acid is placed on it. Tell the class that calcite may be the cement of a sedimentary rock or may form an entire sedimentary rock such as limestone. Ask the pupils how to identify a rock that has calcite in it.

   Place the formula for calcite $CaCO_3$ *on the board. Ask the pupils to suggest what the bubbles may be. Point out that they are* CO_2.
3. Distribute the materials to each group of pupils.

Homework

1. Look up a definition for the word conglomerate. Why is this word a good name for the sedimentary rock called conglomerate?
2. How does sandstone differ from shale?

3. Why does limestone accumulate most abundantly in shallow coastal regions?

4. *What properties of the particles in shale enable them to be packed so tightly together?*

5. *Look in your home, school, and neighborhood and make a list of objects composed of sedimentary rocks.*

Materials

Concrete
Conglomerate
Sandstone
Calcite
Dilute hydrochloric acid

(May be duplicated for use by pupils)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 7

Problem: How do we identify sedimentary rocks?

Materials

Rocks: conglomerate, sandstone, shale, limestone, coquina, halite (rock salt)
Dropper bottles of dilute (10 :1) hydrochloric acid
Hand lens (10x)
Beaker with water
Paper towels

Procedure and Observations

1. Sedimentary rocks can be formed by the cementing of fragments of other rocks.
    a. Look at the conglomerate (#______).
        1) Examine it. Are the particles in the rocks large, medium, or fine?
        2) Can you recognize any of the pieces? Name some. __________________
        3) What igneous rock could these fragments have come from? __________
    b. Examine the sandstone (#______). (Use the hand lens.)
        1) Is the size of the particle in the rock large, medium, or fine? ________
        2) Describe any particle you may recognize. ________________
        3) How does the rock feel? ________________

c. Look at the shale (#______).
  1) What is the size of its particles? ________________
  2) Is the particle in this rock pebble, sand, or clay? ________________
  3) How does this rock feel? ________________
  4) Place a drop of water on this rock and smell it. Describe the odor. ____

d. *Using the medicine dropper, place a few drops of water on the conglomerate, the sandstone, and the shale. Which rock absorbs the water fastest?* ____________________________ *Next?* ____________________________
The finer the particles, the more closely packed will be the rock. Therefore, there will be less space between the particles. What effect will this have on the amount of water absorbed into the rock? ____________________ ____

2. Sedimentary rocks can be formed from the remains of once living plants and animals.
  a. Examine the coquina (#______).
    1) What does it appear to be made up of? ________________
    2) Add a few drops of acid to the rock. Does it bubble? ________________
    3) What mineral does this rock contain? ________________

3. Sedimentary rocks can be formed by the evaporation of water from deposits of minerals:
  a. Look at limestone (#______).
    1) What color is it? ________________
    2) Add a few drops of acid to the rock. Does it bubble? ________________
    3) What mineral does this rock contain? ________________

  b. Examine the halite (#______).
    1) Describe its shape. ________________
    2) How does it feel? ________________
    3) Add a few drops of acid to the rock. Does it bubble? ________________
    4) Does halite contain calcite? ________ Why? ____________________
    5) Your teacher will give one pupil a clean piece of halite to taste. Write down what halite tastes like. ____________________________________

Conclusion

1. List 3 sedimentary rocks that were formed by cementation of fragments.

2. List a sedimentary rock formed by the accumulation of animal remains.

3. List 2 sedimentary rocks formed by evaporation.

4. What is shale formed from?

5. Describe how you can determine if a rock contained calcite.

6. *Explain why the shale absorbs little or no water.*

7. *What bubbles are given off when calcite ($CaCO_3$) reacts with acid?*

8. HOW ARE METAMORPHIC ROCKS FORMED?

Outcomes

- Sedimentary and igneous rocks within the earth's crust can change to form metamorphic rocks.
- The forces that cause the formation of metamorphic rock are heat, pressure, and chemical reaction.
- *The forces of metamorphism cause rocks to become denser or foliated, or to produce new minerals not found in the original material.*

Motivation

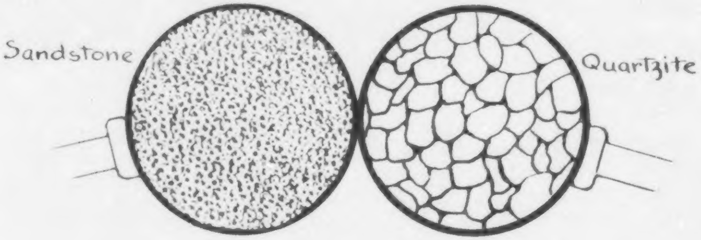
Display a piece of clay that has been dried and a similar piece that has been fired (kiln-fired or heated in a crucible or clay flower pot). Ask, "Which is harder and stronger? Why?"

Development

1. Tell pupils that holes drilled in the earth and deep mines show an average increased temperature of 1°F for every 70-75 feet of depth. "How does increased temperature affect rocks deep in the earth?"
2. Heat some gypsum (plaster of Paris) in a dry test tube. Hold a cold plate over the mouth of the test tube. Ask, "What happens? Where did the water come from?" Lead the pupils to understand that this is an example of how some rocks give up water which then dissolves other minerals to form a new mineral.
3. "How does pressure affect change in rock?"

Demonstration: Inflate several balloons and place them in a glass container (battery jar or fish tank). Use cover to push down with increasing pressure. "What happens to the shape of the balloons? Do the open spaces between balloons increase or decrease?" Conclude that great pressure squeezes rock particles together to make a more compact, denser rock.

Show class a diagram or transparency of two rocks, both containing the same material—quartz. Ask, "Which is the metamorphic rock? Why?"



Compare granite (igneous) and gneiss (metamorphic) rocks. Both contain mica, quartz, and feldspar.

NOTE: Granite looks like pepper and salt.
Gneiss has alternate light and dark bands.

Elicit that although they have the same materials, the arrangement is different.

Illustrate foliation by taking a boxful of toothpicks and breaking each toothpick in half. Place them all in a paper bag and shake it. Pour the toothpicks in a pile on the table. Have the class note the arrangement of the toothpicks (irregular, random). Place a book on top of the toothpicks; press down heavily. Have the pupils describe the arrangement of the toothpicks. (They are flatter, on one plane, and lined up.) Point out that this alignment of minerals appears to be made up of layers and is called foliation (Latin: leaves). Tell them that this extreme heat and pressure may also produce new minerals not found in the original rock.

Display slate and shale. Break the slate and note how it splits into sheets. Point out that heat and pressure on the shale caused the minerals to line up in layers. Display some mica schist and point out that this mineral, too, was formed from shale.

Summary

1. What are the forces that produce metamorphic rocks?
2. Explain how the various rocks can be converted into metamorphic rocks.
3. Where are metamorphic rocks formed? Why?
4. *Explain why sandstone breaks around the grains whereas quartzite breaks through the grains.*
5. *Explain how schist illustrates the metamorphic characteristic known as foliation.*
6. *Explain how slate illustrates the metamorphic characteristic known as foliation.*
7. *Explain how gneiss illustrates the metamorphic characteristic known as banding.*

Homework

1. Rocks near an accumulation of magma are metamorphosed to greater extent than rocks farther away. Can you explain why?
2. What property of slate makes it useful as a building material?
3. How would you prove that marble is formed from limestone?
4. *What general statement can you make about the depth of mine extracting metamorphic rocks as compared to mines extractin igneous or sedimentary rocks? Explain your answer.*
5. *What general statement can you make about the density and hardness of a metamorphic rock as compared to its "parent rock"? Explain your answer.*

Materials

Beaker of cold water
Gypsum (plaster of Paris)
Several small balloons
Large glass container
Board to cover containers
Specimens of granite, gneiss, slate, shale, schist

Clay object
Fired clay object
Test tube, 6"
Box of toothpicks
Paper bag

9. HOW CAN WE RECOGNIZE METAMORPHIC ROCKS?

LABORATORY LESSON

Outcomes

- Metamorphic rocks may be recognized by the fact that some form bands or layers of minerals and others are crystalline in structure.
- Metamorphic rocks that contain the mineral calcite can be identified by the acid test.
- *Some metamorphic rocks can be compared to their parent rocks except that they are harder and denser.*

Motivation

Display large samples of gneiss. Elicit that the minerals in gneiss are arranged in wide bands. Point out that this is one way to recognize a metamorphic rock.

Development

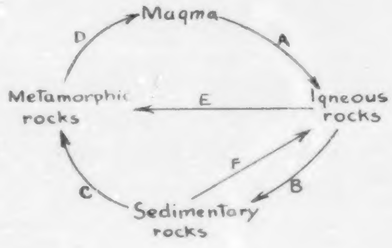
. Recall that temperature and pressure increase with depth. These factors cause banding. What are other ways of recognizing metamorphic rocks?

Distribute the Worksheets and direct the pupils in the performance of the investigations.

Homework

Look at your house and neighborhood and locate an example of metamorphic rock.

One class of rocks may become another through a series of events. On top of each arrow fill in the event which causes one type of rock to become another.



3. Explain why it is or is not possible to make a diamond from coal.
4. *Explain why metamorphic rock may or may not be the best type of building material.*

Materials

Specimens of gneiss

(May be duplicated for use by pupils)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 9

Problem: How do we recognize metamorphic rocks?

Materials

Rocks: gneiss, slate, schist, quartzite, marble, anthracite coal, granite, sandstone, shale, bituminous coal, limestone
Minerals: quartz, mica
Dilute hydrochloric acid (dropper bottle)
Hand lens
4″ x 4″ glass plate

Procedure and Observation

1. Look at the gneiss (#______).
   a. Describe its appearance. ______________________
   b. What mineral do you recognize in the light bands? ______________

2. Look at schist (#______).
   a. Are the bands thinner or wider than those in gneiss? ______________
   b. If you can peel off flakes of minerals, what mineral is it? ____________
   c. Can you detect any quartz in the schist? ______________________

3. Examine the slate (#______).
   Is its appearance smooth or rough?

4. Look at marble (#______).
   a. Add a drop of dilute HCl. Does it bubble? ______________
   b. What mineral reacts with the acid? ________________
   c. What is the gas that is given off? __________________
   d. What sedimentary rock could marble have come from? ____________

5. Examine the quartzite (# ______) with your hand lens.
   a. The crystals of what mineral make up this rock? ________________
   b. Does it scratch glass? ________________
   c. Add acid to quartzite. Does it bubble? ________________
   d. What does this prove? ____________________________

6. Look at the anthracite coal (#______).
   a. Is it shiny or dull? ________________
   b. Is it hard or soft? ________________
   c. Compare anthracite with bituminous coal (#______).
   d. Which is softer? ________________
   e. In what other ways can we compare them? ________________

7. *Gneiss is believed to originate from granite (#______).*
   a. Compare the two rocks. How are they similar? ______________________
   b. How do they differ? ______________________________________

8. *Slate is derived from shale (#______). Compare the two as to color, odor, hardness, smoothness, and splitting.*

Summary

1. Make a list of methods of identifying metamorphic rocks.
2. How was hydrochloric acid used in this experiment?
3. *Why can we say that gneiss is derived from granite?*
4. *If schist is most commonly formed from shale, how can you account for the new minerals formed in it?*
5. *What is quartzite derived from?*

REVIEW AND REINFORCEMENT (1—9)

The instructor may select the most suitable of the following suggestions for review and reinforcement.

Multiple Choice

1. From the center to the surface, the earth has four layers

a) outer core, inner core, crust, mantle.
b) outer core, crust, mantle, inner core.
c) crust, mantle, outer core, inner core.
d) mantle, crust, outer core, inner core.

2. As we move toward the center of the earth
   a) the temperature will increase and the pressure will decrease.
   b) the temperature will decrease and the pressure will increase.
   c) the temperature and pressure will decrease.
   d) the temperature and pressure will increase.

3. Which of the following is a mineral?
   a) sugar b) quartz c) coal d) pearl

4. Hematite is an ore which contains the metal
   a) oxygen b) iron c) calcium d) aluminum.

5. Dull, waxy, metallic, glassy are words used to describe a mineral's
   a) luster b) color c) streak d) hardness.

6. Rocks formed from molten material that solidified on cooling are
   a) igneous b) sedimentary c) metamorphic d) quartz

7. Which of these is a sedimentary rock?
   a) quartz b) granite c) sandstone d) pumice.

8. One of the best things to use to test for calcite is
   a) a hammer b) a magnifying glass
   c) a streak plate d) hydrochloric acid.

9. Slate is a metamorphic rock probably formed from
   a) granite b) shale c) sandstone d) flint.

10. A rock which forms from accumulation and cementing of pebbles is
    a) conglomerate b) calcite c) shale d) gneiss.

Report Topics

1. Project "Mohole"
2. Minerals Used for Jewelry

3. Mining and Processing Various Ores
4. Gems
5. Uses of Various Rocks and Minerals
6. Double Refraction of Iceland Spar
7. Crystal Forms

Projects

1. Growing of crystals
2. Collection of rocks and minerals
3. Uses of fluorescence to identify minerals
4. Identification of unknown minerals

Films and Filmstrips

Rocks and Minerals (*Understanding Our Earth Series*). 11 minutes, Coronet, 1957.
Explains the characteristics of the three classes of rocks.

Our Earth. 13 minutes, Cenco, 1963.
Shows that the planet is made up of land, water, and air. Also describes the three layers of the interior. Discusses the major type of rocks.

Rocks: Where They Come From. 11 minutes, Coronet.
We learn that some rocks are made by heat, some by water, and others are made from other rocks by pressure.

Project "Mohole" (*Planet Earth Series*). 21 minutes, E.T.S., 1959.
Film shows the first stages of Project "Mohole."

Rocks for Us (Filmstrip). Item 37591.22, Heath.
The varied uses of rocks are explained and illustrated.

THE CHANGING EARTH

10. WHAT CAUSES THE EARTH'S SURFACE TO CHANGE?

Outcomes

- The surface of the earth is constantly being worn down physically and chemically by the atmosphere, plants, and animals.
- *Physical weathering breaks rocks into smaller pieces.*
- *Chemical weathering changes the minerals in the rock.*

Motivation

Hold up a piece of quartz in one hand and a beaker of sand in the other. Tell the class that this sand came from the quartz. Ask, "How do you think this happened?"

Development

1. Demonstrate the effect of the freezing of water in confined spaces with an ice bomb. Fill the bomb with water and seal it. Cover the bomb with a plastic bag and place it in the freezer for 15 minutes. Discuss the cracking of water pipes and milk bottles during the winter, and the developing of large holes in city streets during the winter and spring. Guide the pupils to see that freezing water can break rocks into smaller pieces.

2. Ask, "What effect do the roots of trees have on sidewalks?" Discuss the problems people have with willow trees growing through foundations and breaking underground pipes. Establish that the roots of plants may break up rocks also.

3. Point out that earthworms, moles, woodchucks, and other burrowing animals dig holes in the ground and allow water to enter. Elicit from the pupils that this water can freeze and cause the rock to break.

4. Display some rusty steel wool. Elicit from the pupils that it is red and crumbles easily. Have pupils recall that rust is iron oxide. Ask, "How did the iron rust?" Point out that rocks which contain iron will also rust and be broken down.

5. Recall that water can dissolve such minerals as halite (salt).

6. Place a small piece of limestone into a test tube with dilute (4:1) hydrochloric acid and have the class observe how the rock will bubble and finally dissolve. Suggest that water will combine with carbon dioxide in the air to form a mild acid. Ask, "What do you think this acid will do to rocks like limestone?" Point out that this acid will dissolve rocks containing the mineral calcite. Tell the pupils that some plants also can make acids that will weather rocks and minerals.

7. *Elicit from the students that frost action, animals, and plants merely break larger rocks into smaller ones but that chemical weathering changes and dissolves the minerals. Demonstrate that breaking the rock into smaller pieces increases the speed of the chemical weathering. Prepare two pieces of limestone about the same size. Pulverize one and then place the crushed pieces and the other small specimen into two separate test tubes of dilute hydrochloric acid. Have the pupils compare the speed at which each dissolves. Relate this to the effect of mechanical weathering on the speed of chemical weathering.*

Summary

1. What is weathering?
2. Give some examples to show how rocks are worn down.
3. *What is the effect of mechanical weathering on rocks?*
4. *What is the effect of chemical weathering on rocks?*

Homework

1. The following are examples of weathering. Explain how they occur.

    a. Some bricks come loose from a building after a cold, wet winter.
    b. Statues turn green and have stains on them.
    c. The sidewalks split near a tree.
    d. A piece of rock has red stains and will crumble in your hand.
2. *Due to frost action, sandstone will weather faster than quartzite. Explain why.*
3. *There is a company that must constantly clean out clogged sewer pipes even though the people take special care not to clog them. What is a possible cause of the clogging of these pipes?*

Materials

Ice bomb (S-1 14-0938)
Plastic bag
Steel wool (rusty)
Halite
Beaker
Limestone
Dilute hydrochloric acid
Test tubes
Mortar and pestle

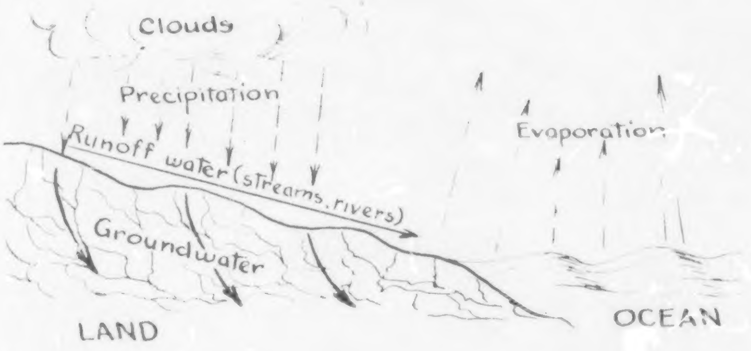
11. HOW DOES WATER WEAR AWAY THE SURFACE OF THE EARTH?

Outcomes

- Erosion is the process of breaking up and removing materials.
- Running water, rivers, and streams are the most effective agents of erosion.
- *The slope of the land and the amount of water will affect the rate of erosion.*

Motivation

Show the class a diagram or transparency of the water cycle. Elicit that some water evaporates from the earth and then condenses and falls back on the earth. Ask, "What will happen to some of the water that falls back on the earth?"



Development

1. Demonstrate how rocks are worn down and broken up by running water which causes the rocks to strike each other. Place several chunks of hardened plaster of Paris and pieces of other rocks into a quart jar half full of water. Cover the jar and shake it for some time. Have the pupils observe that some of the plaster and rocks have been broken down. Ask, "How has abrasion changed these rocks?" Point out that water moving downhill will cause rocks to smash and rub up against each other.

2. Elicit that rocks can also be eroded by wind, frozen rivers, underground water, and water moving at the seashore. Of all the agents of erosion, however, running water is the most effective.

3. Demonstrate the formation of gullies and river valleys with a three-foot eaves trough (rain gutter). Fasten a piece of one-eighth inch wire mesh to the bottom end. Fill the trough with gravel, sand, and clay. Set the trough on a slight incline and pour water on the upper end. (Use a powdered sugar shaker so that the water will not fall too quickly.) Guide the pupils to see that the running water digs grooves. These are called gullies and in time they will become river valleys.

4. *Demonstrate with the eaves trough, that the greater the slope of the land, the faster the stream will move and the greater will be the rate of erosion. Do this by elevating the eaves trough. Have the pupils compare the rate of flow of the water. Then have them compare the depth and width of the "valley." Have the pupils also note the amount of sediment which collected at the lower end of the trough.*

5. *Repeat the foregoing procedure, using same slope, but increase the amount of water (use 2 cans of water at the same time). Compare the amount of erosion and elicit that the greater the volume of water, the greater the rate of erosion.*

NOTE: If time permits, use the eaves trough to illustrate features, such as delta formation, stream meanders, oxbow lake, alluvial fan, flood plain, and waterfalls. (See NYS *Earth Science Handbook*, pp62-63, or NYS *General Science Handbook*, Part 2, pp.140-141.)

Summary

1. How is erosion different from weathering?
2. Explain how running water erodes the land.
3. Explain how a gulley is formed.
4. *What are two important factors which determine the rate of erosion?*
5. *Of the particles placed in the jar, which seem to be affected most by the agitation. Why?*

Homework

1. Why is water erosion such a great problem to the farmer?
2. Using the information learned today, explain how the Grand Canyon was formed.
3. What are some forces that wear away the land?
4. Draw a labeled diagram of the water cycle.
5. *List four factors that will determine the rate of erosion caused by running water.*

Materials

Quart jar with cover
Pieces of plaster of Paris
Pieces of gravel, sand, clay
Eaves trough (rain gutter)

Wire mesh
Stand and clamps
Powdered sugar dispenser

12. WHAT HAPPENS TO THE WATER THAT SEEPS INTO THE EARTH?

LABORATORY LESSON

Outcomes

- Some water that falls onto the earth may seep into the ground and collect there as *groundwater.*
- Different soils transmit water at varying rates.
- *Groundwater may move beneath the surface of the earth.*

Motivation

Ask the class, "Is it a fact that after a rainstorm puddles form on the street or in the gutter but rarely on an area of dirt or soil?"

Development

1. Demonstrate that water falling on the earth will seep into the ground by pouring water into a beaker half-filled with soil.
2. Distribute the materials to each group of pupils.

Homework

1. Explain how some homes develop leaks below street level.
2. When does ground water stop seeping downward?
3. Water from the surface has been found in rocks as far down as two miles. Why doesn't this water penetrate even farther down?
4. *What is an artesian well? Make a diagram or clay model of one.*
5. *Explain how an oasis in a desert can have a lake.*
6. *What gas found in groundwater helps the water to dissolve limestone?*

Materials

Beaker

Soil

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 12

Problem: What happens to water that enters the ground?

Materials

3, 6" test tubes with rack
Sand, gravel, clay
Demonstration lift pump
1000ml beaker or battery jar
Glass chimney tube
Quart of water

Procedure and Observation

1. To find out if different soils transmit water at varying rates:
    a. Place clay into one test tube, sand into another, and gravel into the third. Each test tube should be filled equally to a height of 3 to 4 inches.
    b. Pour equal amounts of water into each test tube. Watch closely.
        1) The water seeped most rapidly into the test tube with the -----------.
        2) Almost no water seeped into the test tube with ----- --------------.
        3) List the order in which each allowed the water to pass through.

2. Water Table:
    a. Place a glass chimney tube inside a large beaker. Place the chimney tube close to one side of the beaker so that you can see into the chimney tube.
    b. Add gravel to the beaker.
    c. Add water to the beaker. (Fill it half full.)
    d. After a few moments, look at the level of the water in the chimney tube and in the beaker.

    The top surface of the water is called the *water table.*

    If you want to sink a well, how deep must the pipe be extended into the ground? ------------------------------------.

    The bottom of the jar stopped the water from going any deeper. If this bottom were sedimentary rock underground, which rock is it most likely to be? (sandstone, shale) ------------------------------.

    If you pump some water out of the tube, what happens to the water table? (If there is a demonstration lift pump available, try it.)

3. *Remove the lift pump and tilt the beaker.*

    What happens to the water within the soil?

If this were a hill, in what direction would the groundwater move?

Compare the speed at which groundwater moves with that of surface water.

Conclusion

1. What determines the rate at which water will seep into the earth?
2. If a farmer wanted to dig a well, how far down would he have to go?
3. *Explain how a cavern is formed in an area that has limestone deposits. Water dissolves CO_2 to form a weak acid.*
4. *During a drought, wells on a hilltop dry up before those lower down on the hillside. Explain why.*

13. HOW HAVE GLACIERS CHANGED THE SURFACE OF THE EARTH?

Outcomes

- A glacier will grind, scratch, or polish the surface over which it moves.
- A glacier moves loosened material within it, and when it melts, it leaves deposits of this material.
- *When snow accumulates, it becomes compressed and changes to form glacial ice.*
- *The center portion of a glacier moves faster than its edges.*

Motivation

Show the class a picture or tell them of giant boulders that are found in Central Park. Point out that they are very different from the other type of rocks found there. Ask class, "How do you think such large boulders got there?"

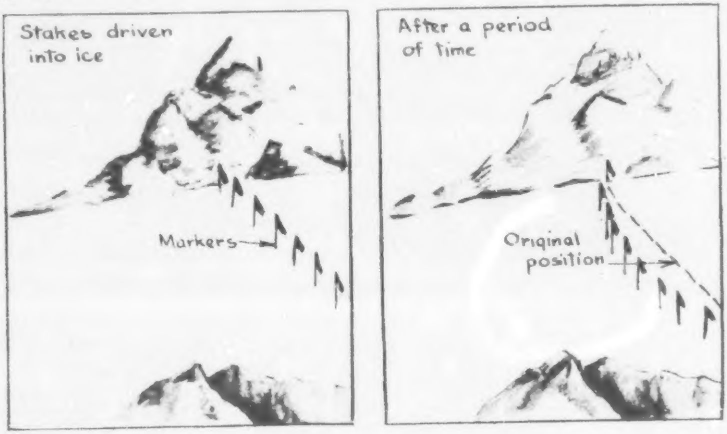
Development

1. Tell the class that a glacier is a moving mass of snow and ice.

Demonstrate how a glacier erodes the surface of the land by moving an ice cube over some sand. Have the class note that the ice acts as a bulldozer moving particles in front of it. Ask, "What will remain after the ice melts?" Tell the class that about one million years ago a large glacier moved down from the north to cover a good part of New York City. Sections such as Crown Heights and Highland Park in Brooklyn are located on top of the mound produced by this glacier. The mound is called a *terminal moraine*.

2. To show how a glacier affects the surface over which it moves, place some sand on an ice cube and move the cube across a piece of soap. Have the class examine the soap and elicit that as a glacier moves, bits of sand or gravel imbedded in the glacier will scratch and groove the surface which it touches. Tell the pupils that fine particles will smooth and polish the surface over which it moves. Show the pupils specimens or pictures of rocks with *striations*.

3. *Display a diagram or transparency of stakes driven across a glacier.*



Tell the pupils that, in the study of glacial movement, stakes are driven in straight rows across the glacier and their positions are recorded over some time period. Ask, "What does the diagram point out about glacial movement?" Elicit from the pupils that a glacier moves faster in the center than at its edges. Guide them to see the reduction of speed is due to friction between the ice and the surface along which the glacier moves.

Elicit that if the snowfall in an area exceeds the amount of snow that melts, the snow will accumulate. Point out that as new snow piles on top of old snow, pressure will be produced and this pressure will cause the snow to melt. Demonstrate this by placing an asbestos square on each of two different ice cubes. On one piece of asbestos place a heavy weight. Have the pupils observe that the cube with the heavier weight will melt faster.

4. *Demonstrate that water formed around ice will refreeze. Apply pressure to two ice cubes held together. Show the pupils that they will stick together. Elicit that the pressure melts some of the ice between the cubes. When the pressure is removed, the water refreezes. Have the pupils recall that as you compress a snowball, it hardens and eventually changes to ice.*

Summary

1. What proof do we have that a glacier once covered parts of New York City?
2. Ice is extremely smooth. How does a glacier erode the land?
3. *What conditions are favorable for the formation and growth of a glacier?*
4. *Explain what happens to snow that forms a glacier.*
5. *Do all parts of a glacier move at the same speed? Explain.*

Homework

1. The north shore of Long Island is very different from the south shore. Describe the features you may find on the north shore and explain how they are formed.
2. Explain how a glacier can grow smaller and finally disappear.
3. Where are glaciers found?
4. Where in the United States would you expect to find glaciers?
5. *Why does the snow melt faster on a street with a great deal of traffic?*
6. *Is glacial ice like a thin sheet of ice which freezes in a puddle? Explain your answer.*

14. HOW DOES THE WIND CHANGE THE SURFACE OF THE EARTH?

Outcomes

- In dry regions, wind will drive hard mineral grains against rock surfaces to wear them away.
- An obstruction may cause the wind to deposit its material and form a dune.
- *A sand dune often migrates in the direction of the wind.*
- *Vegetation often prevents the wind from transporting surface material.*

Motivation

Sandpaper a rough piece of wood. Guide the pupils to see how a powder is produced. Ask, "How does this illustrate the process of erosion?"

Development

1. Elicit that wind causes sand particles to wear away the surface of the earth. Tell the pupils how some buildings are cleaned by sandblasting. Have pupils recall how their faces sting when the wind blows sand at them. Show the pupils pictures of balancing rocks and sculptured rocks.
2. With an electric fan or vacuum cleaner, blow air across a pile of dry sand and moist sand. Guide the pupils to see that the dry sand was moved more easily than the moist sand. Elicit that wind erosion will take place most often in a dry region Display a world map and ask the class to locate regions on the earth where wind erosion is now taking place.
3. Demonstrate how a sand dune is formed by pouring a pile of sand on the bottom of a large carton. (See NYS *Earth Science Handbook,* p 67.) Direct a fan or the exhaust of a vacuum cleaner toward the pile of sand. Then place an obstacle, such as a pencil in the path of the blowing sand, and have the pupils observe how a dune is formed. Guide the pupils to see the gentle slope of the *windward* side and the steep slope of the *leeward* side. Show the class pictures of desert scenes, including sand dunes.

4. *With the aid of a transparency large diagram, show the pupils how sand moves up the windward face of a dune and falls down the leeward face. Point out that, as this particle movement continues, the dune migrates. Ask how this movement presents a problem in building highways along beach areas.*

5. *Demonstrate how vegetation helps to prevent soil erosion from the wind. Direct a fast-flowing stream of air over 2 boxes. One box should be devoid of vegetation; the other box should have some seed grass or clover planted in it. (Grass seed, clover, and birdseed should take about 3 days to germinate.) Have the pupils observe that the soil with the vegetation was not eroded. Elicit that the vegetation prevented the soil from eroding because it acted as a windbreaker, kept moisture in the soil, and held the ground together.*

Summary

1. In what kind of climate is the wind effective as an agent of erosion?
2. Describe how the wind acts as an agent of erosion.
3. Describe how a sand dune is formed. Draw a diagram of one and label it.
4. *In what direction does a sand dune migrate?*
5. *Explain how a sand dune migrates.*
6. *Explain how vegetation can prevent the eroding of the land by wind.*

Homework

1. In a desert region a telephone pole has a pile of rocks at its base to prevent erosion of the pole. Explain why this is done.
2. Where in New York is evidence of wind erosion found?

3. *What does the Park Department do to prevent wind erosion at the beaches?*

4. *Describe the shape of dunes in an area where the winds constantly come from one direction.*

Materials

Sandpaper
Wood piece
Electric fan or vacuum cleaner
Large carton
Two planting trays
One pound of fine sand

15. HOW DO WAVES AFFECT THE FACE OF THE LAND?

Outcomes

- Along the shores, waves pounding against rock will cause erosion of the land.
- Most waves are caused by winds.
- *The motion of waves creates features, such as beaches, offshore bars, and lagoons.*

Motivation

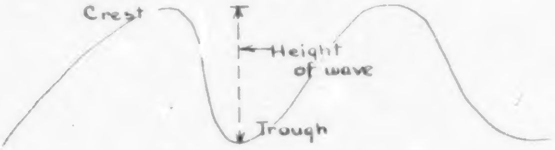
Ask pupils to recall a day at the beach. Elicit that when they stand in the surf, the sand is washed out from under their feet. Ask, "How do waves affect the land?"

Development

1. To show how waves are developed, fill a pan with water and blow across the top of it. Have the pupils observe what happens and elicit that the friction between the wind and the water wrinkles the water and produces waves. Demonstrate by blowing harder that the stronger the winds, the higher the waves. Have the pupils recall that the sea is rough on a very windy day.

2. Secure a 12-foot rope or spring to some stationary object, such as a doorknob. Take the other end and flip it up and down so that a

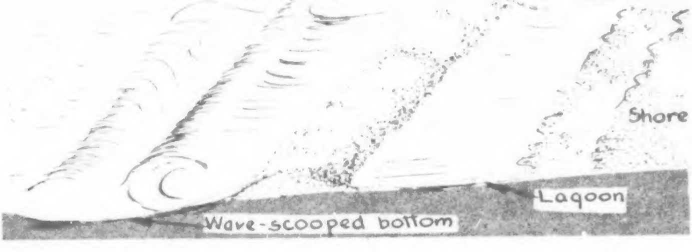
wave moves along the rope. Have the pupils draw a diagram of a wave in their notebooks. Tell them that each wave has a top called the *crest* and a bottom called a *trough.*



Point out that the height of a wave is the distance from the trough to the top of the crest. Tell them that some waves are over 50 feet high. Ask, "What determines how high a wave rises?"

3. Demonstrate how waves are able to erode the shore. Add sand or gravel to the fish tank. Build up a slope at one end of the tank. Add water slowly to the other end and then agitate the water to produce waves. Have the pupils note movement of the sand. Elicit that the sand is being moved or eroded from the beach into the water. Have pupils recall, from the lesson on running water erosion, that water can supply the energy to cause rock particles to smash against other rocks and break them down.

4. *With the aid of the diagram of the wave, elicit that when a wave moves into shallow water the trough will scrape along the bottom. Point out that it may scoop up some bottom sand and move it forward to form an underwater* SANDBAR. *With time, this bar will grow above sea level to produce an* OFFSHORE BAR *running parallel to the shoreline.*



Display a map of Brooklyn and Long Island. Elicit that Rockaway, Long Beach, and Jones Beach are all offshore bars. Tell the pupils that the quiet water behind the bar is called a lagoon.

Summary

1. Why are rough seas usually accompanied by windy weather?
2. How do we determine the weight of a wave?
3. Explain how waves erode the land.
4. *Define sandbar, offshore bar, and lagoon.*
5. *Explain how each is formed.*

Homework

1. Steep shorelines have many sea caves. How are they formed?
2. What is meant by the statement: The shoreline is retreating.
3. Explain how it is possible for the sea to have waves on a day when the weather is fair.
4. *Describe the appearance of an offshore bar regarding size, height, shape, and location.*
5. *Locate several offshore bars on a geodetic map of the United States.*
6. *Locate several lagoons.*

Materials

Pan of water
12-ft. rope or spring
Fish tank
Sand or gravel
Map or transparency of Brooklyn and Long Island

16. WHY IS THE OCEAN SALTY?

LABORATORY LESSON

Outcomes

- The oceans receive the erosional products that come from the land.
- The water of the ocean is a solution of dissolved salts.
- *Sediment is distributed unevenly over the ocean bottom.*

Motivation

Have the pupils recall swimming in the ocean and getting a mouthful of seawater. Ask, "How did it taste?"

Development

1. Ask the pupils why the ocean is salty. Elicit that rivers, ground water, and glaciers carry tons of rocks and minerals into the ocean.
2. Tell the pupils that in this laboratory lesson they will find a method of identifying some of the dissolved substances in seawater. Distribute the materials and guide the pupils in performing the activity.

Homework

1. Make a list of the elements that are found in seawater.
2. List all agents of erosion that carry rocks and minerals into the ocean.
3. *Explain how the size of the particles determines where the particles will be deposited on the ocean floor.*

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 16

Problem: How may we find out the composition of seawater?

Materials

2, 150ml beakers or evaporating dishes
Bunsen burner or canned heat
Ring stand and asbestos pad
Tap water
Seawater or artificial seawater*
Flame test wire loops
Cobalt glass
5% silver nitrate solution
Eyedropper
2 test tubes
Large jar
Pebbles, sand, gravel, soil

*Artificial seawater—Made by adding these chemicals to 1000ml water:
27gm sodium chloride 1.8gm magnesium sulfate 1.2gm calcium sulfate
3.5gm magnesium chloride 0.9gm potassium sulfate

Procedure and Observation

1. To prove that seawater contains dissolved minerals:

   Place some seawater into one beaker (or evaporating dish) and some tap water into another. Place the beakers, one at a time, over a very low flame and evaporate the water in each beaker. When the seawater gets to about ¼ inch from the bottom, stop heating it and let the heat of the beaker do the final evaporation.

   a. What do you observe at the bottom of the beakers? ____________________
   b. Which beaker has the most material in it after the liquid has evaporated?
   ____
   c. What is this material which remains after the water evaporates?
   ____
   d. Where did it come from? ______________________________

2. To identify some of the substances dissolved in seawater, use a flame test:

   Dip the wire loop into the seawater and then hold the wire in a flame.
   a. What color do you observe?
   b. If you get an orange-yellow color, sodium is present. Is sodium present in your sample of seawater?

   Dip the wire into the water again and observe the flame through the piece of cobalt glass.
   a. What color do you observe?
   b. The presence of potassium colors a flame lavender-pink. Cobalt glass filters out the yellow, allowing you to see a potassium flame. Is there any potassium present?

3. To test for chloride in seawater:

   Place some seawater into one test tube and some tap water into another test tube. Add several drops of silver nitrate to each.
   a. What did you observe in the test tube with tap water? ________________
   b. What did you observe in the test tube with the seawater? ________________

   (Chloride (Cl^-) will form a white precipitate when silver nitrate is added to it.)
   c. What did you prove about the seawater in this test? ____________________
   d. Why did we add the silver nitrate to the tap water? ____________________

4. *To demonstrate that sediments are distributed unevenly:*

   Place about ½ cup of sand, soil, pebbles, and gravel into a large jar of water. Cover the jar and shake it up. Allow it to stand and observe how the particles settle out.

   List the order in which the particles settle out. ______ ______ ______ ______

Summary

1. Why did we use tap water in procedures 1 and 3?
2. In procedure 2 how could we have proven that only seawater could have produced the flame colors?
3. *When a river empties into the ocean, which particles drop out nearest to shore?* ---------------------------------- *next?* ---------------------------------- *farthest from shore?* ----------------------------

17. HOW IS THE EARTH'S CRUST BUILT UP?

Outcomes

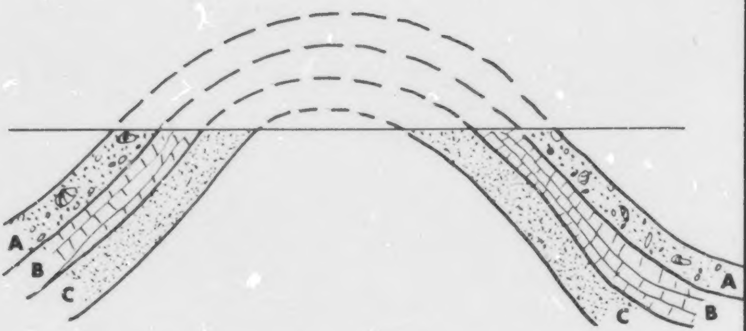
- Remains of marine animals on mountaintops serve as evidence of crustal growth.
- Pressure, heat, and movements of the earth's crust form mountains.
- Earth movements may cause the crust to fold.
- *Heat in the earth's interior produces convection currents in the molten layer of the mantle that compresses the crust.*

Motivation

Tell the pupils that remains of marine animals have been found more than 20,000 feet up in the Himalayan Mountains. Ask, "How does this show evidence of a change in the earth's crust?"

Development

1. Allow the pupils to speculate that an ocean may have covered the top of these mountains or that the land may have moved up over a long period of time. Tell the class that additional evidence will be useful in solving this problem. Show a transparency or diagram of tilted strata.



Point out that sediments are usually laid down in horizontal layers. Tell the class that we find layers that are tilted. Connect the strata to show that there existed a mountain which had been eroded. "If animal remains existed in layer A, where would they be found in the remains of that mountain?" Have the class conclude that animal remains found on the tops of mountains could have only gotten there by the upward movement of the earth's crust.

2. Refer to the diagram of the tilted strata and ask, "How do you think these layers became tilted?" Take a package of 12″ x 18″ colored construction paper. Ask, "What do the various layers of colors represent?" Push the ends of the package together. Have the pupils compare their observations with the diagram or transparency. Show pictures of regions with folded rocks.
3. Show, using layers of clay of various colors, that, as you exert a force on a plastic material, it will bend and fold. Elicit that the mantle of the earth has a plastic consistency and that heat and pressure from the earth's interior cause the crust to fold.
4. *Use the following demonstration to show convection currents Drop a crystal of potassium permanganate into a beaker of water Heat the beaker gently and have the class note the movement of the colored material within the solution. Elicit that the heat of the earth can set up convection currents, and mountains may form if the earth's crust is pushed together due to pressure caused by convection currents.*

Summary

1. Why hasn't erosion worn down the continents so that all of the land is level?

2. How do the following prove that the land rose?
   a. Marine shells on beaches hundreds of feet above the coastline
   b. A sea cave on top of another sea cave
   c. Sedimentary rock on top of mountains
3. Draw a diagram of a folded rock region.
4. *What are convection currents?*
5. *How are convection currents in the earth responsible for folding?*

Homework

1. What are some evidences from the past that parts of the earth's crust has been raised?
2. What are some of the major sources which cause the earth's crust to form mountains?
3. *Explain how convection currents are developed within the earth.*

Materials

Silly putty	12″ x 18″ colored construction paper

18. HOW ARE EARTHQUAKES CAUSED?

Outcomes

- Internal pressure of the earth's crust can cause a break or crack, called a *fault*, in the rocks.
- A sudden movement of the ground which produces a vibration or shaking is called an *earthquake*.
- A *seismograph* is an instrument used to determine the location and intensity of an earthquake.
- *The crust of the earth appears to be floating on a plastic mantle. The transfer of material from the continents to the ocean floor can cause the uplifting of the continents.*

Motivation

Experts are convinced that California is racing toward several major earthquake disasters. They are likely to strike the state's two most heavily populated areas: Los Angeles and San Francisco. Dr. Charles Richter of the California Institute of Technology, father of the famed Richter scale for measuring earthquake magnitude, states that he would not be surprised if a major quake devastated part of California tomorrow. Ask pupils to describe an earthquake.

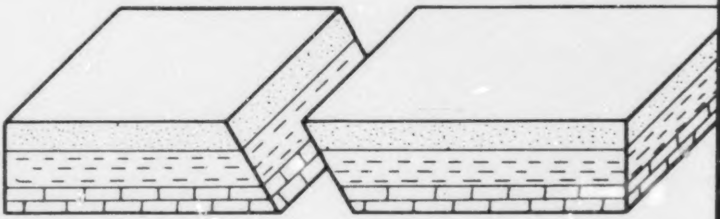
Development

1. Ask, "Why is an earthquake so destructive?" Refer to (or show pupils) newspaper clippings or photos of earthquake disasters. Point out that much of the loss of property and life is caused by the fires that follow.

2. Demonstrate the nature of the mantle with *Silly Putty*. Pull the putty apart slowly. Ask, "What causes the putty to stretch?" Elicit that the putty is plastic similar to the earth's mantle and that a force exerted slowly will cause the putty to change its shape. Now quickly pull the putty apart. The putty snaps. Ask, "How does this demonstration illustrate how an earthquake occurs?"

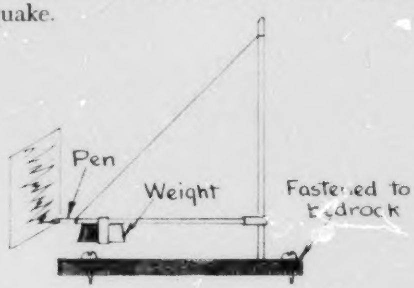
3. Tell the pupils that internal pressure in the earth's crust can cause a break or crack in the ground and one part of the earth slides past the other. This is called a *fault* and the movement of the rocks is called *faulting.*

   Demonstrate faulting with models (block of wood painted in layers). Place them side by side and move them horizontally and vertically in opposite directions. Point out that a sudden movement of the ground caused by faulting is called an earthquake.

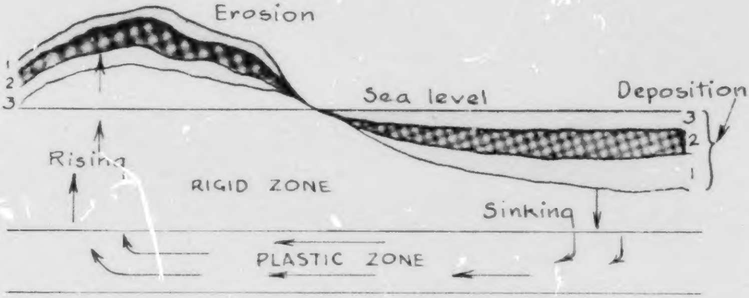


See N.Y.S. *Earth Science Handbook*, p. 75.

4. Ask, "How do we measure earthquake intensity?" Demonstrate a model of a *seismograph* as shown in the diagram. Point out that the base of the instrument will move with the earth, but the heavily weighted beam will remain in place. A pen attached to the heavy weight records, on paper, the magnitude of a vibration. Have the pupils note that this seismograph measures sideward movement of the earth and another type of seismograph, with a spring, is used to measure up and down vibrations of the earth. Show an actual *seismogram*, if it is available, and tell the class that the instrument that produced it can be used to locate and measure the intensity of an earthquake.



5. *Explain the theory of* ISOSTASY, *which accounts for the rising of land to great heights. Stack about 20 wood checkers (alternate the colors) in a graduate cylinder. Add enough water so that the stack of checkers floats as high as possible. Have pupils note the level at which the bottom checker rests. Remove one checker at a time and have the pupils note how the bottom checker is affected. With the aid of the following diagram or transparency, compare this to the continents floating on a plastic layer of earth.*



Summary

1. What is meant by faulting of rocks?
2. How are earthquakes produced?
3. Draw a diagram of a seismograph and explain how it operates.
4. *How does the theory of isostasy explain the formation of mountains?*

Homework

1. Why is it important to have earthquake recorders?
2. Make a list of areas that have earthquakes.
3. *How are continents affected as sediments are carried from the land to the ocean?*

Materials

Models to demonstrate faulting
Model of seismograph
Seismogram

Silly Putty
Graduated cylinder
20 wooden checkers

19. HOW HAS VOLCANISM CHANGED THE EARTH'S SURFACE?

Outcomes

- Volcanoes or lava flows result when pressure in the earth's interior pushes magma toward the surface.
- Volcanoes may occur as quiet flows of lava, violent eruptions, or a combination of both.
- Volcanoes build up the land by pushing magma onto the surface through weak spots in the crust.
- *Molten rock which does not reach the surface will push the surface upward or squeeze itself between rock layers.*

Motivation

Into a metal cup or small crucible place some granular ammonium dichromate. (Add a few sprinkles of ammonium chloride to make smoke.) Insert a two-inch magnesium ribbon into the chemical. Light the "fuse" of magnesium ribbon with a Bunsen flame until it burns vigorously. Ask the pupils to explain the purpose of this demonstration.

CAUTION: Move pupils away from the demonstration. Warn pupils not to look directly at the burning magnesium ribbon.

Development

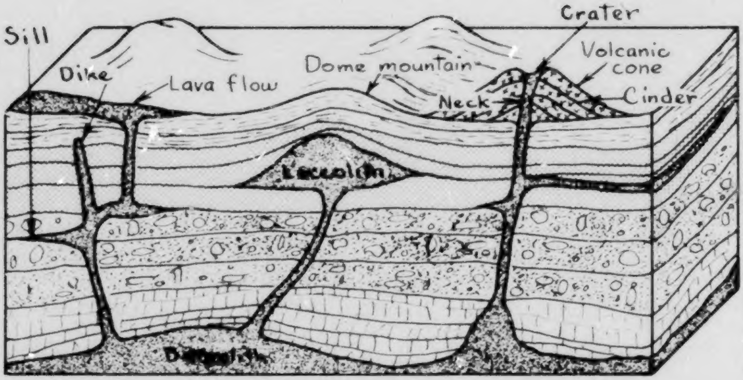
1. Have the pupils note the steep cone that is built up with the ashes. Elicit from the pupils that molten material coming from a volcano will build up the surrounding area. Tell them that it is called a *cinder cone*.

2. Point out that in order to make the volcano work a chemical was placed in the center. Ask, "Where does the molten material come from in a real volcano?" Have the pupils recall that as you go deeper into the earth, the pressure and temperature increase. Elicit that this heat and pressure push the magma toward the surface.

3. Display a piece of granite and pumice. Tell the class that both of these rocks came from molten *magma*. Elicit that granite is formed inside the earth whereas pumice is formed outside. Ask, "How do you account for the fact that some rocks are formed on the surface of the earth while others are formed inside?" Point out that some magma is forced through weak spots in the earth's surface, causing volcanic eruptions.

4. Elicit that the opening in the earth's crust through which the lava comes is called a volcano. Show pictures or slides of the various types of volcanoes. Point out that Mt. Katmai in Alaska is an explosive volcano with a steep cinder cone, whereas Mauna Loa in Hawaii is a quiet volcano with a gentle lava slope. Tell the pupils that most volcanoes are both gentle and explosive. Relate to the pupils some famous volcanic eruptions that have taken place on the earth.

5. *With the aid of a diagram or transparency, discuss the formation of intrusive volcanism.*


Sill
Dike
Lava flow
Dome mountain
Crater
Volcanic cone
Cinder
Neck
Laccolith
Batholith

Point out that there are enormous storehouses of magma located in the earth's crust. If this magma does not reach the surface, different types of underground formations result. (Examples of these are sills, dikes, laccoliths, batholiths, and domed mountains.)

Summary

1. How do volcanoes build up the land?
2. Where does the lava come from?
3. What makes the lava come out of the ground?
4. Describe the three types of volcanoes and give an example of each.
5. *Define the following:*
   - a. batholith
   - b. laccolith
   - c. volcanic core
   - d. sill
   - e. dike
   - f. crater
   - g. domed mountain
   - h. lava flow
   - i. neck

Homework

1. What happens to lava when it cools?
2. What is the difference between a quiet volcano and an explosive one?
3. How were the Hawaiian Islands formed?
4. *Draw a diagram of an area of volcanic activity. Include all features*

that might be found within the crust as well as those found on the surface.

Materials

Metal cup or crucible
Ammonium dichromate
Magnesium ribbon
Bunsen burner
Ammonium chloride
Granite
Pumice

REVIEW AND REINFORCEMENT (10—19)

The instructor may select the most suitable of the following suggesions for review and reinforcement.

Multiple Choice

1. The element in the air which combines readily with many other elements and compounds in rocks is
   a) oxygen b) hydrogen c) silicon d) iron

2. Freezing of water causes rocks to break because
   a) the rock is changed c) water freezes in the cracks and expands
   b) the rock contracts d) a chemical change results.

3. A good way to stop sand from blowing on beaches is to plant grasses which will
   a) act as wind screens
   b) hold the sand together with their roots
   c) change the nature of the sand chemically
   d) add water to the sand

. The process by which land areas are worn down and carried away is known as
   a) weathering b) corrosion c) explosion d) erosion.

5. A body of quiet, shallow water trapped between an offshore bar and the coast is a
a) barrier beach b) estuary c) lagoon d) stack

6. A mound of sand deposited by waves parallel to a shoreline but not attached to it is a (an)
a) atoll b) offshore bar c) fringing reef d) breaker

7. Seismographs are used in the study of
a) earthquakes b) floods c) tides d) stars

8. The breaking and slipping of rocks is called
a) folding b) faulting c) dome construction
d) outcropping

9. The cuplike depression at the top of a volcano is called a
a) dike b) crater c) neck d) cone

10. Volcanoes of the oozing or quiet type are characteristic of
a) Japan a) Mexico c) Hawaiian Islands
d) West Indies

Suggested Projects

1. Formation of stalactites and stalagmites can be demonstrated b placing the ends of a piece of string in two beakers filled with saturated solution of magnesium sulfate (Epsom salt.) After a da or two, along the exposed surface of the string, concentrations magnesium sulfate will form stalactites. Drippings of magnesiu sulfate from the string will form stalagmites on the table beneat (NYS *Science Handbook*, Part 2, pp. 140-141.)
2. Use modeling clay or plaster of Paris to make models of glaci features, such as eskers, kames, drumlins, arete, matterhorn, cirqu etc.
3. Use an eaves trough to illustrate river features. (NYS *Earth Sc* *ence Handbook*, pp. 62-62 or *General Science Handbook*, Part pp. 140-141.)
4. Show the difference between hard and soft water. Distilled wat may be used for soft water in one bottle. A dilute solution of ma nesium sulfate or calcium sulfate may be used as hard water in

second bottle. Add liquid soap to both bottles drop-by-drop and shake until suds form and remain. Compare the sudsing ability of both. Add several drops of water softener to the hard water. (Borax or sodium carbonate can be used.) Repeat the procedure, using a detergent instead of soap.

Report Topics

1. Conservation Methods to Stop Erosion
2. Grand Canyon, Niagara Falls, Yellowstone, Yosemite, etc.
3. Geysers and Hot Springs
4. Artesian Wells
5. Caves and Caverns
6. Types of Shorelines
7. Soils
8. Location of Earthquake Belts
9. The Birth of a Volcano

0. Tsunamis

rip

rips through the neighborhood show examples of weathering and ero-
ion. Have the pupils note cracks in the sidewalk, rust on the side of
uildings, roots pushing up sidewalks, paint peeling, etc. If the school
near a bridge or overpass, look for the formation of stalactites. Cem-
teries with old tombstones display remarkable effects of weathering.
or other suggestions regarding field trips, see *Operation New York*,
urriculum Research Project, Board of Education of the City of New
ork, reprinted 1966.

lms and Filmstrips (BAVI)

rosion (*Leveling the Land*) (C) 14 min., E.B.F.
lm shows the processes of weathering, erosion, and deposition of
ck materials.

Glaciers (*Understanding Our Earth Series*) 11 min. Coronet, 1952.
Animation is combined with selected scenes of glaciers and glaciation to show how glaciers are formed and to present evidences of glacial action.

How Its Surface Changes (*Understanding Our Earth Series*) (C) 11 min. Coronet, 1956.
Film shows the eruption of the Paracutin volcano and Grand Canyon.

Mountains on the Move (C) 11 min. Pictura, 1955.
Film illustrates the formation of mountains. It also shows the effects of heat, cold, water, glaciers, etc., of mountains.

Volcano 17 min. Sterling, 1959.
The subject of volcanoes is discussed, and scenes of volcanoes, such as Moana Loa, Fujiyama, Vesuvius, and Mt. Etna, are shown.

Volcanos in Action 11 min. E.B.F., 1935.
Animated drawings and natural photography demonstrate distribution, causes, and effects of volcanic eruptions, cone types, lava flow extinct and active.

Earthquakes and Volcanoes 20 min. F.A.C., 1957.
The film describes the causes and relationships between volcanoes and earthquakes.

Changes in the Earth's Crust (Filmstrip). Item 37390.11.
McGraw-Hill
Illustrates changes as effected by weathering, erosion, and diastrophism

Changing Surface of the Earth (Filmstrip). Item 37023.13.
McGraw-Hill
Demonstrates the force of erosion and the building up of sub-surfac pressures which change the surface of the earth.

THE IMPORTANCE OF FOSSILS

20. WHAT EVIDENCE IS THERE THAT LIFE EXISTED ON THE EARTH MILLIONS OF YEARS AGO?

Outcomes

- Fossils are the remains or evidence of animals and plants that lived on the earth millions of years ago, although many organisms leave no evidence of their existence because they decay or are eaten.
- Flesh and other soft tissues of plants and animals have been preserved in ice, tar pits and amber.
- *Fossils show us that species of animals change as time goes on.*

Motivation

Tell the pupils that it has been reported that a group of Russian explorers found and ate meat from an animal which had been dead for over 11,000 years. Ask the pupils, "How is this possible?"

Development

1. Ask the pupils, "Would you eat a piece of meat which is almost one million years old?" Show pictures or discuss the story of mammoths. Tell the class about the 1901 Siberian find. The mammoth had a yellowish skin under its long brown hair and preserved inside its stomach was 27 pounds of chewed, but not digested pine cones, wild flowers, grass, herbs, and moss. Elicit that freezing preserves flesh. Compare this to modern frozen foods.

2. Demonstrate how animals were caught in tar pits. Prepare a very thick, sticky fluid (tar, tree-wound paint, or molasses). Tie a string onto a piece of chalk and drop the chalk into the fluid. Guide the pupils to see how the chalk sinks into the fluid. Point out that many such tar pits can be found in nature, as for example, La Brea (tar ranch), California. Ask pupils, "How does this demonstration illustrate another way in which the remains of ancient animals are preserved?" Elicit that animals might wander into a tar pool covered with water and be caught and pulled down into it. Show pictures of the *Smilodon* (saber-toothed tiger), camels, mammoths, mastodons, giant ground-sloths, bison, bears, dire wolves (prehistoric wolf), and tell the pupils that the remains of these animals have been removed from the Los Angeles tar pits.

3. Demonstrate how insects and flowers became trapped in resin. Elicit that a very sticky sap will flow from a pine tree. If possible, have students examine the sticky resin of a freshly cut pine branch. Tell the students that shellac comes from this resin. Place some shellac on a piece of cardboard and drop a small object, flower, or piece of string into the shellac. Ask the pupils, "How could this produce a specimen to be preserved for many years to come?" Elicit that a small insect could have been trapped in the resin after landing in a tree. Show the pupils insect specimens preserved in plastic. Have the students examine a piece of amber which is hardened resin. Tell the pupils that the remains or evidence of animals and plants that once lived on this earth are called *fossils*.

4. Ask, "If an animal were to fall dead in a forest what would be his chances of becoming a fossil?" Why? Elicit that his chances of being preserved are very poor because he might be eaten by other animals or his body might decay. Guide the pupils to see that fossils or original remains are very rare.

5. *Show a picture of a woolly mammoth and an elephant. Have pupils compare similarities and differences of both. (Larger curled tusks and fur on body of mammoth) Compare saber-toothed tiger with a modern-day tiger. Point out that those fossils have helped scientists trace the development or evolution of these animals.*

Summary

1. What is a fossil?

2. List several ways in which fossils may have been formed.
3. Why are the original remains of animals so rare a form of fossil?
4. *Evolution tells us that animals have changed through the ages. How can you prove or disprove this statement?*

Homework

1. How long can you keep frozen foods safely in the freezer of your refrigerator?
2. What important facts have we gotten from the LaBrea tar pits?
3. Why are foods vacuum packed?
4. Prepare a list of prehistoric animals. Try to illustrate this list with drawings or pictures.
5. *Compare several prehistoric animals with their present-day relatives.* (Hint: horse, tiger)

Materials

Tar or tarry fluid
String
Branch of pine tree
Shellac

21. HOW ARE SOME FOSSILS FORMED?

Outcomes

- Most fossils we find consist mainly of the hard parts of plants and animals or impressions left by them.
- Most fossils are found in sedimentary rock.
- *Porous shells or bones may be petrified when dissolved minerals are deposited in the pores of these objects or when the original structure is replaced by another mineral.*

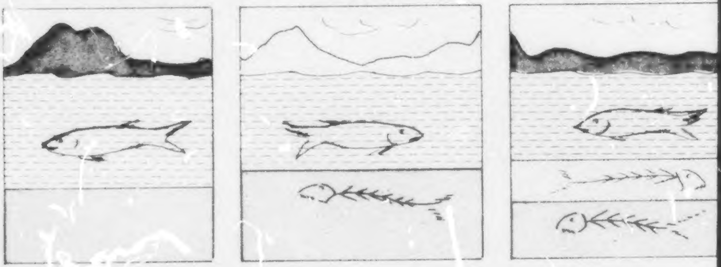
Motivation

Have pupils recall that some areas that are now mountains were once at the bottom of a shallow sea. Ask, "What evidence do we have to prove this?"

Development

1. Ask, "How are fossils formed in shallow seas?" Demonstration: In a box of fine sand make a shallow depression, and drop a bone, shell, or other object into the depression. Then direct a fine stream of water onto the sand that surrounds the hole. Guide the pupils to see how the sand covers the object. Elicit from the pupils that the object must be a hard substance; otherwise, it would decay before it had a chance to be covered.

2. With the aid of a diagram or transparency, show the class how fossils are formed in sedimentary rocks.

   Ask the pupils the names of the various types of sedimentary rocks. Tell them that the fossils found in shale are much easier to recognize than those found in sandstone. Elicit that very fine sediment is ideal for producing fossils. Display a fern fossil in shale.

3. Distribute enough clay to each pupil to fill the cover of a large jar. Have the pupils flatten the clay on a piece of toweling. Then hand out shells or other hard objects. Have the pupils press the objects into the clay and then remove the objects. Pour plaster of Paris, of a creamy consistency, into each mold. Elicit from the pupils that the clay represents the ocean bottom and the shell an ancient animal which has just died and fallen to the bottom. The plaster of Paris represents minerals dissolved in seawater replacing the shell. Put plaster of Paris fossils away for the next laboratory lesson.

ADVANCE PREPARATION

Prepare, 3 or 4 days beforehand, the following materials for a demonstration of the petrification process. Melt paraffin in a pyrex beaker. Soak 2 cellulose sponges (about 1″ x 1″ x 4″) in melted paraffin. When paraffin has hardened, dissolve one of the sponges in concentrated nitric acid in another beaker. (The paraffin will remain.) *Use extreme caution.* Make small holes in the specimen with a dissecting needle to hasten penetration of the acid. The cellulose will dissolve in 3 to 4 days. Discard the acid. Rinse with water. Then pour thin plaster of Paris into the paraffin sponge and let it harden. (The plaster should replace the original material of the sponge.) Heat the paraffin-plaster "sponge" at a very low temperature to melt and remove the paraffin. The plaster specimen should look like the original sponge.

---

4. *Display a cellulose sponge and the plaster sponges. Ask the pupils to hold each sponge and describe it. Elicit that even though all look alike, two are harder than the original which is of a different material. Tell the pupils how you made the two sponges. Point out that some porous shells and bones become fossils by permineralization, that is, by being filled with minerals (e.g., the sponge impregnated with paraffin), while others are formed by replacement of the original components (e.g., the plaster sponge). Pass around some petrified wood and point out that it was formed by replacement.*

Summary

1. Make a list of the various types of fossils.
2. Which of the three classifications of rocks would have the most fossils?
3. Why do most fossils consist mainly of the hard parts of plants and animals?
4. How are these fossils formed?
5. *Explain the process of permineralization.*
6. *Explain the process of replacement.*

Homework

1. Why are fossils found mainly in sedimentary rocks?
2. If you were to bury a dead bird, would it become a fossil? Explain.
3. *Explain how a seashell originally composed of calcite may be found composed of a completely new material.*
4. *Why is the sea such a good place for fossil formation?*

Materials

Fine sand
Hose with fine jet
Shells or bones
Clay
Bunsen burner or electric heater
3 cellulose sponges
Plaster of Paris
12″ stick or ruler
2 small pyrex beakers
250ml beaker
Paraffin
Nitric acid
Petrified wood

22. HOW CAN WE IDENTIFY FOSSILS?

LABORATORY LESSON

Outcomes

- Fossils are often found in the form of impressions.
- Molds show the shape of the original organism imprinted on rocks.
- Casts are formed by minerals which fill the molds.
- Some preserved fossils are found as footprints or other marks.
- Many fossils can be related to modern forms of life.

Motivation

Hold up a skeleton of a fish or a chicken's wing and ask class if they can describe the animal (where it lived, how it moved, its size, etc.) from the sample shown.

Development

1. Elicit from the pupils that the mystery the paleontologist is trying

to solve is the description of life as it existed in ancient times. Point out that his clues are the fossil remains he finds.

2. Hand out the clay molds and plaster casts prepared by the pupils during the previous lesson. Distribute a set of fossils to the pupils for examination.

Homework

1. What evidence do we have to prove that the following lived in prehistoric times?
   a. trilobites
   b. saber-toothed tiger
   c. insects
   d. woolly mammoth
   e. brachiopod
   f. trees
   g. ferns
2. Of the various types of fossils mentioned which one would you say is the most abundant? Explain your answer.
3. *How do fossils reveal the climate of a prehistoric region? Give an example to illustrate your answer.*
4. *Explain why a fossil can or cannot be found in a volcanic region (e.g., Pompeii or Mt. Vesuvius).*

Materials

Large specimens of fossils for display
Sets of specimens for laboratory exercise (S-1 12-4118)
Samples of shellfish (may be purchased at a neighborhood fish store)

(MAY BE DUPLICATED FOR USE BY PUPILS)

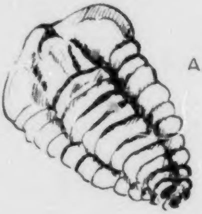
LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 22

Problem: How can we identify various fossils?

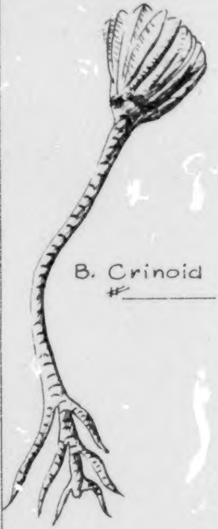
Materials

Student-prepared molds and casts
Numbered fossil specimens (trilobite, brachiopod, crinoid, fern, cephalopod, coral gastropod, echinoderm)
Specimens of clam, snail, nautilus shells, starfish, coral, fern
Chart of common fossils

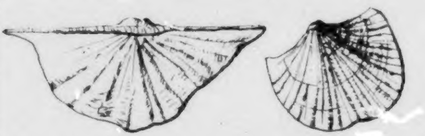
TYPICAL FOSSILS



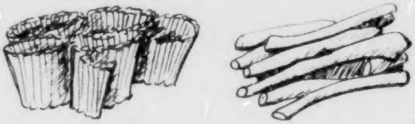
A. Trilobite
#__________



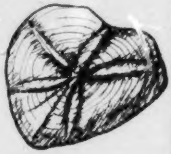
B. Crinoid
#__________



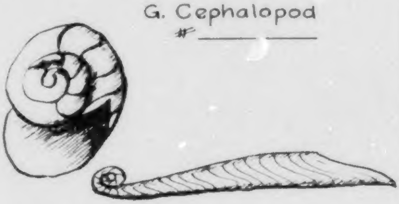
C. Brachiopods
#__________



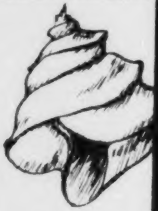
E. Coral
#__________



D. Echinoderm
#__________



G. Cephalopod
#__________



F. Gastropod
#__________

Procedure and Observation

1. Remove the plaster of Paris from the clay. *Take care not to destroy the impression in the clay.* Describe what you see in the clay.

   How could this *mold* or *impression* be considered a fossil?
----

2. Examine the plaster of Paris *cast*. Describe it. --------------------------
How can a cast be formed naturally to produce a fossil? ----------------
Name several ways, other than shell imprints, that animals may leave fossil imprints, molds, or casts. --

3. *Fossil A* on your chart is called a *trilobite*. It is number -------------- of your specimens. It lived about one-half billion years ago. Touch it. Describe how it feels. ------------------------------------. Is it a cast or mold? ----------------------. Crabs, lobsters, and crayfish are probably related to the trilobite. Describe any similarities you may see. ------------------
----

   Fossil B on your chart is *crinoid*. It is number --------- of your specimens. This animal looked like a plant. Which part of the animal does your fossil come from? ------------------------------

   Fossils C are examples of *brachiopods*. Your specimen is number -----------. Is it a mold or cast? ----------------- What modern animal is this similar to? -----------------------

   Fossil D is an *echinoderm*. Specimen number -------------- is the one that looks most like this diagram. Is this a mold or cast? --------------------- Why? -------------------- What modern animal does this fossil resemble?

   Fossil E is *coral*. What number is the fossil coral? -------------- Coral are animals found in warm sea water. If you find fossils of this animal, what does this tell you about the ancient climate? ------------------------------

   Fossil F is *gastropod*. It is number -------------- and resembles a modern --------------------------------

   Fossil G is a *cephalopod*. It is number ----------- and -----------. Today the cephalopods resemble the nautilus. The squid and octopus are also cousins to your fossil cephalopod; however, they have lost their shells.

   Look for the fossil fern. Your specimen is numbered -------------------.

Summary

1. Even though no bones or traces of bone have been found in an area, scientists have to be able to prove that dinosaurs lived there. They have also been able to describe the size and weight of the animals of this area. How is this done?

2. Where would you look to find fossils?

3. What is a mold?

4. What is a cast?

5. Complete the chart:

Number	Modern Specimen	Fossil Name
	Clam	
	Snail	
	Starfish	
	Fern plant	
	Crayfish, lobster	
	Coral	

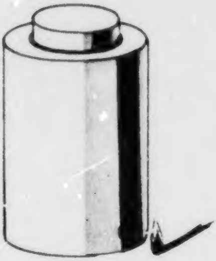
23. WHY ARE PETROLEUM AND COAL CALLED FOSSIL FUELS?

Outcomes

- Coal is the end product of a metamorphic process whereby prehistoric plants changed from peat to lignite, then to bituminous, and finally to anthracite coal.
- Petroleum probably comes from tiny marine animals and plants.
- Natural gas is often found with oil.
- *Fossils give us a clue to past climates and other environmental conditions.*

Motivation

Use a can (baking powder or tobacco) with a friction lid, having a hole punched on the side near the bottom. Hold up the lid of the can. Ask, "Can the remains of living things shoot the top of this can several feet into the air?" Place a few drops of gasoline in the can, replace the cover, shake the can to vaporize the gasoline, and ignite the mixture by placing a long taper at the hole at the bottom.



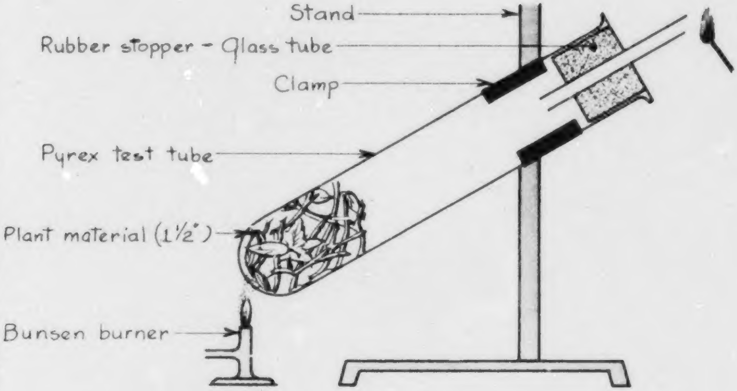
CAUTION

1. *Try this experiment, before performing it in class, using 4 to 5 drops of gasoline.*
2. *Stand clear! The lid will be ejected with considerable force.*
3. *DO NOT REPEAT this demonstration until the can has cooled.*
4. *Do not bring more than 10ml of gasoline into the classroom and keep the container stoppered and away from a flame.*

Tell the pupils you proved that the remains of a living thing can cause an explosion. The pupils should object and point out that it is gasoline and not a dead animal that caused the explosion. Tell the pupils that gasoline came from fossilized sea animals.

Development

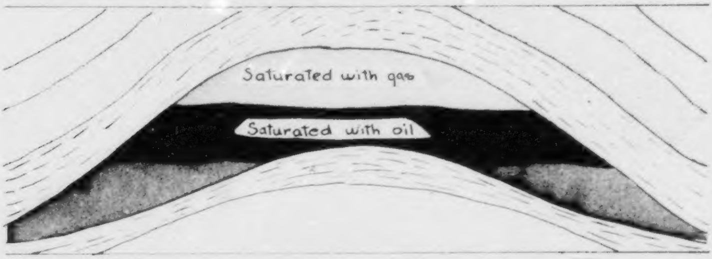
1. Tell the pupils that petroleum and coal are called fossil fuels. To demonstrate that plant material can be broken into the element carbon and other compounds, place some plants, twigs, leaves, pine needles, etc., into a test tube which has a tightly fitted stopper and a glass tube inserted in it.



Heat the test tube for a few minutes until smoke begins to come out of the glass tube. Try to light this gas with a lighted splint. (If the light goes out, light it again as water vapor coming out of the tube tends to extinguish the flame.) Keep heating the tube and guide the pupils to observe that material inside the test tube turns black. Elicit that the black residue in the test tube is charcoal. Point out that charcoal is a form of carbon, and so is *coal.*

2. Ask, "How do you think coal can be formed naturally?" Distribute samples of peat, lignite, bituminous coal, and anthracite coal to groups of pupils. Guide the pupils to see that peat and lignite are made up of loose pieces of plant material. Elicit that these specimens are made up of sediments of plant material. Point out that peat and then lignite represent an early stage of coal formation and that they formed millions of years ago as plant material died and began to form sediments in marshes and swamps.
3. Have the pupils compare the bituminous and anthracite coal. Elicit that the anthracite is harder and denser. Ask, "What type of rock is bituminous coal?" Have the pupils conclude that anthracite coal is a metamorphic rock and that it was changed from sedimentary bituminous coal by heat and pressure over a long period of time.
4. With the aid of a drawing or tranparency, show that scientists believe that crude oil was formed in ancient swamps or seas when marine plants and animals were covered with sediment. The chemical and physical changes produced oil from the bodies of these marine animals.
5. Using the conclusions of the demonstration in which plants, twigs, and leaves were heated, elicit that if heat and pressure are added to fossil fuels, natural gas will form.

   With the above illustration, point out that natural gas and oil are usually discovered together.



6. *Tell the class that coal has been found in the Antarctic. Ask, "What does this tell you about the climate of Antarctic in prehistoric times?" Elicit that finding coal and oil in an area tells us that the region was once rich in vegetation or sea life. Discuss the types of environments associated with fishbones, shell fossils, dinosaur bones, salt deposits.*

Summary

1. What is a fuel?
2. Why is coal called a fossil fuel?
3. Describe the steps in the formation of anthracite coal.
4. What element do we find in all fuels?
5. What type of rock is bituminous coal? anthracite coal?
6. How is oil formed?
7. Why do we find natural gas with oil?
8. *Describe the ancient climates of the following areas:*
   a. *marine fossils in Texas*
   b. *coral fossils in Maine (Coral will live in shallow, warm seas.)*
   c. *coal deposits in Pennsylvania*
   d. *salt deposits in New York (Salt will form in very dry climates.)*

Homework

1. Is it true that when we burn coal we are using the sun's energy?
2. How did coal and oil get so deep into the earth?
3. *List some areas where formation of coal may be beginning.*
4. Drillers consult geologists and paleontologists when looking for oil. Why?

Materials

Percussion can
Gasoline
Splints
Stand
Large test tube
One-hole rubber stopper
Glass tubing
Bunsen burner
Plant material (twigs, pine needles, leaves)
Samples of peat, lignite, bituminous coal, anthracite coal

24. WHAT DO FOSSILS REVEAL TO US ABOUT PREHISTORIC LIFE?

Outcomes

- Life has existed on the earth for a very long time.
- Some forms of life disappeared and were replaced by other forms.
- Fossils can be used to develop a geological timetable.
- *The concentration of salt in the ocean is used to determine the age of an area.*

Motivation

Relate this incident to the pupils:

On the morning after a violent thunderstorm, a group of primitive people came upon the skeleton of a monster bird which was imbedded in the rock. Its head had a long bony crest and its wings, which measured about 20 feet across, had claws. The people concluded that this giant bird, which they called a thunderbird, had been struck by lightning the night before and had fallen with such a great force that its bones became partly imbedded in the rocks.

Ask the pupils for their reaction to this story.

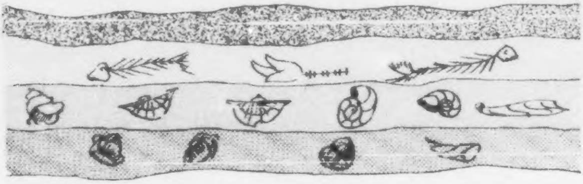
Development

1. Elicit from the pupils that fossils form in sedimentary rocks and sedimentary rocks may form layer upon layer. Obtain separate pictures of a trilobite, a dinosaur, and a modern animal. Using several textbooks, place one on the table and the picture of the trilobite on top of the first book. Cover this picture with another book, placing the picture of the dinosaur on top of this one. Finish by placing the modern animal on top of this book and then cover it with the last book. Point out that the books represent layers of sedimentary rocks and the pictures represent the remains of animals. Elicit from the pupils that the oldest layer is on the bottom and the newest on the top. Show the diagram or transparency used in Lesson 20 to illustrate the concept known as the *Law of Superposition*. Ask the pupils which animal is the oldest and which died most recently.

2. Tell the pupils that various methods are used to calculate the age of the sedimentary strata of the earth. List them on the board as (a) rate of deposition, (b) rate of erosion, (c) amount of salt in an ocean area, and (d) use of radioactive minerals. Use an egg timer (sand glass) to illustrate how the rate of deposition or erosion may be used to determine the age of a sedimentary strata. Point out that if the rate of deposition in an area is known to be fairly constant the following will hold true. Measure the height of the sand in the bottom section of the timer. Tell the pupils that it takes 3 minutes to reach this height. Ask the pupils, "If you know the rate at which sediments are being deposited, how can you calculate the age of the strata?"

3. *One of the older and less reliable methods of determining age is to find concentrations of salts. Ask, "How can the concentration of salt in the ocean be used to judge the age of an area?" Elicit that run-off water has transported tons and tons of mineral material in the ocean. Evaporate the water from 2 beakers which contain different concentrations of salt. Weigh the precipitates. Point out that the greater concentration may be due to the fact that over the years more and more mineral material has been carried into the ocean. Elicit that the higher the concentration, the older the region. Point out that factors such as increased flooding or years of dry spells will affect deposition, erosion, and salt concentration. Ask, "What effect would this have on our age calculations?"*

4. Elicit from the pupils that fossils and coal found in lower strata of sedimentary rocks prove that life existed on the earth for a very long time. Using a diagram or transparency, point out that some fossils are only found in a particular layer of rock. Elicit that this proves that these animals lived only at this time and then became *extinct*. Ask the pupils to explain what extinct means and to give some examples of animals that have recently become extinct. Show pictures of dodo birds, passenger pigeons, dinosaurs, etc.



5. Using a chart or transparency, show that scientists have devised a timetable of the earth's history. Emphasize the following points:
   a. The timetable is divided into long periods of time called eras.
   b. According to fossil finds, different forms of life appeared at different times.
   c. Life also existed before the Paleozoic era. The fossil record is scarce, however.
   d. Dinosaurs had died out long before man appeared on the earth.
   e. Fossils of certain plants and animals can be used to determine the age of rock strata.
   f. The fossil record is far from complete.

TIMETABLE OF EARTH'S HISTORY

Era	Began	Lasted	Evidence of Life as Shown by Fossils
Cenozoic (Age of Mammals)	63 million years ago	63 million years	Modern man, cattle, mammals, modern horse, camels, elephants, primates, flowering plants
Mesozoic (Age of Reptiles)	230 million years ago	167 million years	Dinosaurs appear, rule, and then become extinct; ancient pine, first birds, and mammals appear; flowering plants appear
Paleozoic	600 million years ago	370 million years	Trilobites appear and then become extinct. Fish appear and rule for a short time. First land animals (amphibians) and then reptiles appear. Insects appear. Shell animals appear and become abundant. Coal forming period
Proterozoic Archeozoic	4 to 4½ billion years ago	3 billion years	Worms, jellyfish, sponges, one-celled animals and plants Formation of the earth

Summary

1. How old is the earth?
2. What are some methods used to determine ages of rock strata?
3. What is the Law of Superposition?

4. Movies show man fighting off dinosaurs. Explain why this could not be true.
5. How can a trilobite be used to pinpoint the age of a certain rock?
6. *Is the ocean getting saltier? Why?*

Homework

1. Dinosaurs became extinct at the close of the Mesozoic era. What could have caused this?
2. Of all living things, which one will live the longest? Why?
3. *Will man change physically as time goes by? Explain your answer and try to make some predictions about what changes may occur.*

Materials

4 books
Several pictures of dinosaurs
Egg timer
Picture of a trilobite
Picture of a modern animal
Ruler
2 beakers of salt water of different concentrations

REVIEW AND REINFORCEMENT (20—24)

The instructor may select the most suitable of these suggestions:

Matching

1. fossils
2. mold
3. trilobite
4. fossil insects
5. petrification
6. woolly mammoth
7. dinosaur
8. coral
9. coal
10. sedimentary rocks

a. fossils are usually found in
b. frozen remains
c. preserved in amber
d. replacement of original material by other
e. giant lizard
f. formed in prehistoric forests and swamps
g. a dinosaur footprint
h. evidence of animals and plants that once lived on the earth
i. warm, shallow seashore
j. very early fossil remains

Suggested Projects

1. Construction of dioramas depicting life during some period of geological time
2. Construction of models of dinosaurs or collection of pictures of them
3. Collection of fossils

Report Topics

1. Loch Ness Monster
2. Coelacanth: The Living Fossil
3. Classification of Plants and Animals
4. Evolution of Various Animals (e.g., horse, camel)
5. Evolution of Man
6. Origin of Life
7. Radioactive Dating

Trips

1. Museum of Natural History
2. Highland Mills, N. Y. Exposed beds of brachiopods can be found along railroad tracks near Pine Hill Road.

Films and Filmstrips (BAVI)

Our Common Fuels. 11 min. Coronet, 1954.
Tells of the origins and uses of common fuels.

Prehistoric Times: The World Before Man. 11 min. Coronet, 1955.
Each of the five geological eras is presented according to its most important geological and biological developments.

Animals of Long Ago (Filmstrip). Item 37310.1. Curriculum Materials.
Discussion of how life began on the earth and how organisms developed into complex ones from simple ones.

Fossils of the Grand Canyon (Filmstrip). Item 37320, Journal Films. Shows types of fossils, how they are formed, and what we learned about our earth and life on the earth from fossils.

Man of Long Ago (Filmstrip). Item 37310.12. Curriculum Materials. Shows how scientists are reconstructing the history of ancient man.

SUGGESTED UNIT EXAMINATION

The following is not intended as a diagnostic or comprehensive measure of the unit. The teacher may use this for review purposes or as a source of questions for a unit examination.

DIRECTIONS: Choose the letter of the term which best completes the statement.

1. The study of the history, structure, and composition of the earth is called
   a) chemistry b) geology c) biology d) physics.

2. Rocks which are formed from the solidification of molten magma are called
   a) igneous b) sedimentary c) metamorphic
   d) minerals.

3. Directly beneath the crust of the earth we will find the
   a) core b) inner crust c) mantle d) inner core.

4. About 70% of the earth is covered by the
   a) lithosphere b) atmosphere c) hydrosphere
   d) ionosphere.

5. The solid portion of the earth is called the
   a) chemosphere b) lithosphere c) hydrosphere
   d) stratosphere

6. Most of the rocks that form the crust of the earth are made up of
   a) minerals b) plants and animals c) ores
   d) sea animals.

7. Galena is a very dense metallic ore of
   a) iron b) aluminum c) mercury d) lead.

8. Hydrochloric acid is used to test for the mineral
   a) quartz b) felspar c) mica d) calcite.

9. Crystal size of minerals in igneous rock depends upon
   a) the chemicals found in the minerals
   b) the minerals that are present in the rock
   c) the rate at which the magma cools
   d) the original size of the minerals.

10. Which of the following is a sedimentary rock
    a) conglomerate b) pumice c) quartz d) granite.

11. The White Cliffs of Dover were formed from the shells of tiny sea animals. The sedimentary rock of this area is probably
    a) sandstone b) limestone c) shale d) conglomerate.

12. The rock formed from heat and pressure within the earth is
    a) metamorphic b) igneous c) sedimentary
    d) minerals.

13. Marble is composed mainly of
    a) quartz b) calcite c) mica d) feldspar.

14. The breaking-up and carrying away of rocks is called
    a) erosion b) cracking c) weathering d) faulting.

15. The main element making up the earth's crust is
    a) nitrogen b) oxygen c) hydrogen d) carbon.

16. A property which is *least* useful in identifying minerals is
    a) streak b) luster c) hardness d) color.

17. When water freezes and turns to ice, the ice
    a) expands and cracks rocks b) causes oxidation
    c) produces a chemical change d) contracts.

18. When the iron in a rock is oxidized
    a) rust formed will make the rock stronger
    b) rust formed will cause the rock to crumble
    c) an acid is formed
    d) the iron turns to steel.

19. Three substances most responsible for weathering are
a) calcite, water, and oxygen b) carbon dioxide, kaolin, and oxygen c) clay, oxygen, and carbon dioxide d) oxygen, acids, and carbon dioxide.

20. The fronts of stone houses are scratched by the same force that
a) forms dunes b) forms rust c) forms carbonic acid
d) forms limestone caves.

21. A geyser is
a) an old man b) hot-water spout shooting out of the earth's surface c) underground stream d) waterfalls.

22. An agent of erosion which causes the greatest change in the earth's surface is
a) moving ice b) running water c) wind
d) temperature changes

23. The water table is
a) the level below which the ground is saturated with water
b) the level above which the ground is saturated with water
c) the level of the bedrock d) another name for sea level.

24. A mineral deposit, shaped like an icicle, that hangs from a cavern roof is called a
a) cone b) travertine terrace c) stalactite d) sink hole.

25. A glacier is principally
a) frozen ground water b) a large quantity of sleet
c) a snow field d) a moving stream of packed ice.

26. A glacier moves
a) fastest along the sides b) fastest at the bottom
c) fastest in the center d) at the same speed throughout.

27. Rockaway, a long narrow strip of land running parallel to the main land, is known as
a) an alluvial fan b) fringing reef c) an offshore bar
d) wave cut terrace.

28. Water between a barrier reef and the mainland is known as
a) a tidal pool b) a lagoon c) a tidal lake d) an estuary.

29. The mineral content of the ocean is due primarily to the
a) transporting of materials by rivers b) melting of glaciers
c) redissolving of minerals from the ocean floor
d) animals in the sea.

30. The chemical found dissolved in greatest abundance in the ocean is
a) quartz b) calcite c) iron d) sodium chloride.

31. The chief cause of earthquakes is
a) caves collapsing b) violent storms c) folding
d) faulting.

32. The instrument used to detect earthquakes is the
a) barograph b) seismograph c) hygrograph
d) thermograph.

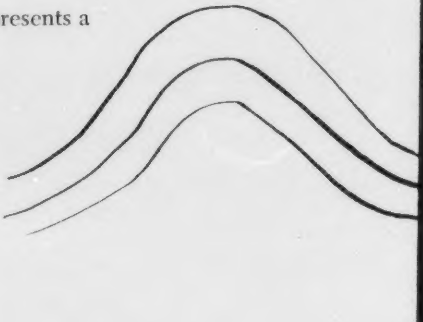
33. The action of waves on a shoreline is
a) only destructional b) only constructional c) both destructional and constructional d) neither destructional or constructional.

34. Ground water containing carbon dioxide reacts as an acid most readily with
a) limestone b) sandstone c) shale d) slate.

35. A landscape feature deposited by a glacier is called a (an)
a) moraine b) iceberg c) fiord d) matterhorn.

36. A crack in the earth's crust along which there has been a movement of rock is called a
a) cave-in b) joint c) crevasse d) fault.

37. The following diagram represents a
a) fold b) fault
c) volcano d) cave.



38. Volcanoes of the quiet or oozing type are characteristic of
a) West Indies b) Hawaiian Islands c) Japan
d) Mexico.

39. Fossils are found mainly in
a) igneous b) sedimentary c) metamorphic
d) mineral rocks.

40. The earth's history can best be studied from
a) living plants b) living animals c) fossils
d) a model of earth.

41. A metamorphic rock that can be used as a fuel is
a) peat b) lignite c) bituminous coal
d) anthracite coal.

42. Rocks which formed first as the earth cooled are the
a) sedimentary b) slate c) igneous d) metamorphic.

43. Animals that lived many years ago, but are not living today, are said to be
a) petrified b) extinct c) distinct d) crystallized.

44. The earliest fossil remains were from
a) trees b) birds c) sea animals d) land animals.

45. A dinosaur footprint is an example of a (an)
a) mold b) cast c) mineral d) ore.

46. As we move toward the center of the earth, the temperature and pressure will
a) increase b) decrease c) remain the same d) vary.

47. If the slope over which a river flows becomes steeper, the rate at which the river will erode will
a) increase b) decrease c) remain the same d) vary.

48. As trees and grass begin to grow along the banks of a river, the rate of erosion
a) increases b) decreases c) remains the same.

49. As we dig into the rock strata of the earth, the age of the fossils found deeper
a) increases b) decreases c) remains the same.

50. If an animal is covered by sediment as soon as it dies, its chances of becoming a fossil
a) increase b) decrease c) remain the same.

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